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FATIGUE EVALUATION OF COMPOSITE - REINFORCED, INTEGRALLY STIFFENED METAL PANELS

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SUMMARY

This report covers the investigation of the fatigue behavior of composite-reinforced, integrally stiffened metal panels. The structural behavior resulting from combining metal and composite materials and subjecting them to fatigue loading was examined. The detail program results are presented in this report and the program summary and conclusion (ref. 1) give a brief description of the program and its findings.

This work made use of existing materials and processes. The material systems investigated are listed below.

- Aluminum-Graphite/Epoxy
- Aluminum-S Glass/Epoxy

Two adhesives were studied to determine the effects of a room temperature cure adhesive and an elevated temperature cure adhesive on the aluminum-graphite system.

The concept of unidirectional composite material sandwiched between aluminum sheet material was examined. Basic composite-metal coupon static and fatigue data was generated and evaluated to determine system fail-safeness and possible weight savings over conventional metal systems. Fatigue metal crack growth in the composite-metal systems was investigated and compared to crack growth in all metal systems. Also the metal crack growth of the aluminum-graphite system was compared to the aluminum-glass system.

After a significant amount of fatigue loading and metal cracking, the panels were pulled statically to failure to determine the residual strength. The results showed that sufficient strength remained to effectively transfer the load from the cracked metal into the composite material and retain a high percentage of its original strength.

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INTRODUCTION

An effective fail-safe structural concept which has application for present and future aircraft systems, such as the space shuttle and advanced technology transports, has been evaluated in this research effort. The all-metal integrally-formed panel concept has shown considerable potential for improving aerospace structures in terms of low manufacturing cost, high-strength capability, low weight, and inherent fail-safe compression failure characteristics (ref. 2). The inclusion of advanced unidirectional composite material between the two sheets of the integrally-formed panel provides for further improvements in reduced metal fatigue crack growth, and increased residual strength at no increase in weight.

The integrally-formed structure consists of two sheets of material, an inner stiffener sheet bonded to an outer face sheet. This panel configuration offers a significant increase in the strength-weight index as compared to the conventional riveted Z panels of the same material and design conditions. By inserting advanced unidirectional composite material between the inner and outer sheet materials before bonding, the composite-reinforced, integrally-stiffened metal panel concept is obtained. This structural concept is illustrated in Figure 1. A panel fabricated in this manner has several advantages over the all-metal and all-composite panels.

This program investigated this unique structural concept using the all-metal integrally-formed panel as a base. Coupon specimens were fabricated and tested in static tension and fatigue to characterize the features of the composite-metal system. Fifteen composite-reinforced, integrally-stiffened metal panels were fabricated and tested in tension-tension fatigue to investigate the metal crack growth rates and panel residual strengths. Two composite-metal systems were examined, 7075-T6 aluminum-graphite/epoxy and 7075-T6 aluminum-S glass/epoxy. The material design limit stresses were taken as 2/3's of the ultimate design allowables. Two adhesives were used to bond the aluminum-graphite system together to evaluate the effects of an elevated cure temperature adhesive, since an elevated curing temperature induces residual thermal stresses in the aluminum. The adhesives used in this investigation were AF-126 (394°K cure (250°F)) and EA-927R (room temperature cure).

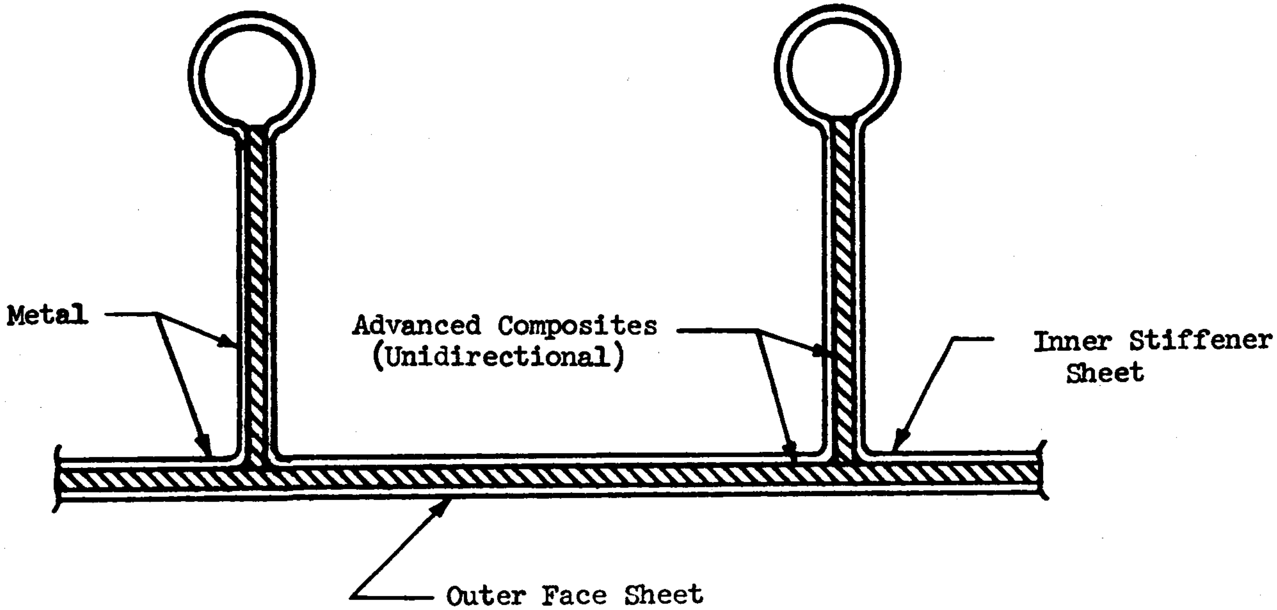


Figure 1 Composite-Reinforced, Integrally Stiffened Metal Panel Structural Concept

SYMBOLS

The physical quantities in this report are given in both the International System of Units (SI) and in the U. S. Customary Units. The SI units are stated first and the Customary units afterwards, in parenthesis. All principal measurements and calculations were made in the U. S. Customary Units. Appendix A presents factors relating these two systems of units.

2a	total crack length, mm (in.)
A	total gross cross-sectional area, mm^2 (in^2)
E	modulus of elasticity, MN/m^2 (ksi)
f	gross stress, MN/m^2 (ksi)
F	gross allowable stress, MN/m^2 (ksi)
F_σ	model stress fringe value for photostress plastic, MN/m^2n (ksi/n)
F_ϵ	model strain fringe value for photostress plastic, mm/mmn (in/in n)
K_t	stress concentration
N	number of cycles of load
n	photoelastic fringe order
P	load, N (lbf)
R	ratio of minimum to maximum values of cyclic load
t	thickness, mm (in.)
W	weight, kg (lbm)
ϵ	strain
μ	ratio of composite stiffness to total stiffness
ρ	density, kg/m^3 ($lbm/in.^3$)

Subscripts

am	all metal
c	composite
c-m	composite-metal

m	metal
max	maximum
t	total
tl	tension limit
tu	tension ultimate

DESIGN CRITERIA

In order to have a degree of fail-safety and not suffer a weight penalty, a design criteria is necessary to provide the sufficient amount of unidirectional composite in the composite-reinforced metal concept. Too much metal will impose a weight penalty and not provide an efficient load-carrying structure. On the other hand, too much unidirectional composite in the system will not work the metal sufficiently to justify its presence as structure. Therefore, establishment of a satisfactory design rationale is a significant part of the composite-reinforced metal structure concept.

The design criteria established in this investigation was that:

(1) The composite material would support the total load at limit stress after the metal had completely failed.

(2) The weight of the composite-metal system would be equal to the weight of an all-metal system which would carry the same total load at limit stress.

Throughout the investigation, it was assumed that the strains associated with the two materials bonded together were equal, i.e., the two materials elongate the same amount under load. Therefore, the strain in each material is

$$\epsilon = \frac{P_m}{A_m E_m} = \frac{P_c}{A_c E_c} \tag{1}$$

If we define a stiffness ratio " μ " for the composite-metal system as

$$\mu \equiv \frac{A_c E_c}{A_c E_c + A_m E_m} \tag{2}$$

then the total load on the composite-metal system would distribute as

$$P_c = \mu P_t \;, \quad P_m = (1-\mu) P_t \tag{3}$$

Consider the weight of a composite-metal structure, W_{c-m},

$$W_{c-m} = \rho_c A_c + \rho_m A_m \tag{4}$$

and the weight of an all-metal structure, W_{am},

$$W_{am} = \rho_m A_{am} \tag{5}$$

for a unit length. Setting the weight of the composite-metal system equal to the weight of the all-metal structure we obtain

$$\rho_c A_c + \rho_m A_m = \rho_m A_{am} \tag{6}$$

or

$$\frac{A_m}{A_c} = \frac{A_{am}}{A_c} - \frac{\rho_c}{\rho_m} \tag{7}$$

Substituting (7) into (2),

$$\mu = \frac{1}{1 + \left(\frac{E_m}{E_c}\right)\left(\frac{A_{am}}{A_c} - \frac{\rho_c}{\rho_m}\right)} \tag{8}$$

To satisfy condition (1) of the design criteria, the composite must carry the total load at limit stress if the metal fails,

$$A_c = \frac{P_t}{F_{t\ell_c}} \tag{9}$$

To satisfy condition (2) of the design criteria, the all-metal system must carry the total load at limit stress, therefore,

$$A_{am} = \frac{P_t}{F_{t\ell_m}} \tag{10}$$

Substituting (9) and (10) into (8), the stiffness ratio becomes

$$\mu = \frac{1}{1 + \left(\frac{E_m}{E_c}\right)\left(\frac{F_{t\ell_c}}{F_{t\ell_m}} - \frac{\rho_c}{\rho_m}\right)} \tag{11}$$

Therefore, knowing the density, modulus of elasticity, and allowable limit stress of a particular composite material and metal, the correct amount of composite and metal can be determined which would satisfy the design criteria conditions (1) and (2) above.

Using the material design properties given in Table I, the stiffness ratio μ for the aluminum-graphite and aluminum-glass systems can be determined using (11). Thus, for the aluminum-graphite system $\mu = 0.57$ and for the aluminum-glass system $\mu = 0.29$.

TABLE I

DESIGN PROPERTIES OF
METAL AND COMPOSITE MATERIALS

MATERIAL	LIMIT STRESS		TENSION MODULUS		DENSITY	
	MN/m^2	(ksi)	MN/m^2	(ksi)	kg/m^3	(lbm/in^3)
7075-T6 Aluminum	359	52	71,000	10,300	2768	0.100
Graphite/Epoxy (HT/S)	696	101	131,000	19,000	1550	0.056
S-Glass Epoxy (1009-26S)	986	143	61,000	8,900	1882	0.068

ADHESIVE STRENGTH

Objective

The objective of this portion of the program was to qualify the double lap shear strength of the bonding adhesives to be used.

Approach

Two types of adhesives were evaluated, an elevated temperature and a room temperature cure adhesive. The elevated temperature cure adhesive produces thermal stresses since the coefficient of thermal expansion of the metal is greater than that of the composite material. The adhesive shear strengths were evaluated in double lap shear tests for the same material combinations as used for the coupon and panel specimens.

Test Specimens

The specimens used in this evaluation consisted of standard double lap shear specimens as shown in Figure 2. Material combinations of aluminum-aluminum, aluminum-graphite, and aluminum-glass were examined. The adhesives tested were AF-126, $394^{\circ}K$ ($250^{\circ}F$) cure, EA-927R, room temperature cure, and EC-1614, room temperature cure.

Testing and Results

The double lap shear specimens were tested in static tension until failure. The failure load of each specimen was recorded and the lap length and width were measured. The shear strength was calculated using the failure load and measured shear area of the lap joint. A summary of the test data in terms of shear strength is presented in Table II.

Discussion

Three adhesives were selected for evaluation for bonding aluminum-aluminum, aluminum-graphite/epoxy and aluminum-glass/epoxy systems: AF-126, EA-927R, and EC-1614. (See Appendix B). These adhesives were selected because of their good shear strength and contain both elevated and room temperature cure characteristics. Because of the large differences in the thermal expansion between the aluminum and graphite/epoxy, high residual thermal stresses may be induced into the system and reduce the bond strength between the composite and metal. The elevated temperature cure adhesive evaluated was the AF-126 and the room temperature cure adhesives evaluated were the EA-927R (film adhesive) and EC-1614 (paste adhesive).

The shear strength of the AF-126 adhesive was evaluated with aluminum-aluminum adherends, aluminum-graphite adherends, and aluminum-glass adherends. The shear strength of the EA-927R and EC-1614 were evaluated with aluminum-graphite adherends.

Table II shows the results of the shear strengths. The AF-126 values are much higher than the room temperature cure adhesives and are equivalent to strengths obtained in present aircraft designs. The aluminum-aluminum adherends gave higher shear strength values than the aluminum-composite adherends. The two room temperature cure adhesives gave the same shear strength values for the aluminum-graphite adherends.

Conclusions

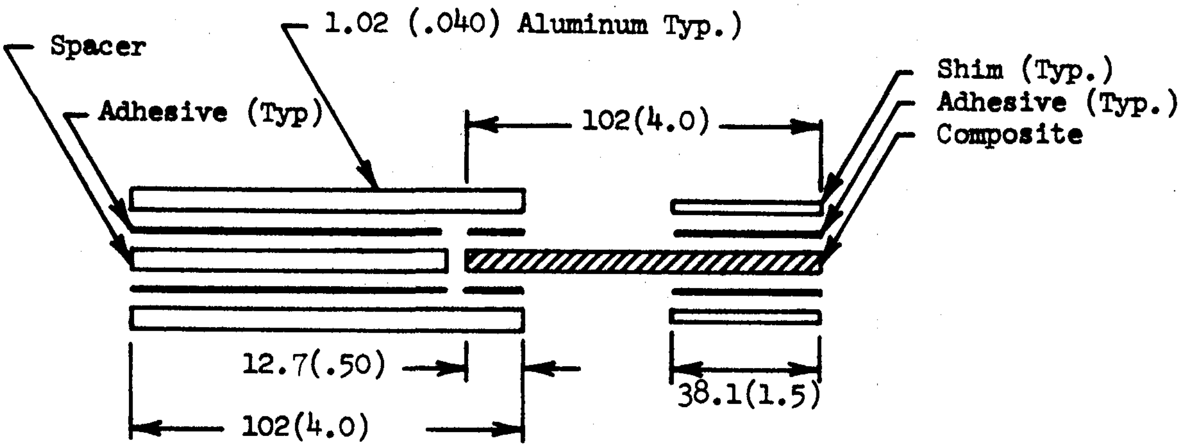
The shear strength of the adhesives tested to bond the aluminum-composite coupons and integrally stiffened panels was equivalent to present values used in aircraft design. The AF-126 (elevated temperature cure) adhesive would be used to bond the aluminum-aluminum, aluminum-graphite, and aluminum-glass systems.

The EC-1614 paste adhesive could not be used to bond the composite-reinforced, integrally stiffened metal panels because of the complexity of the panel configuration. Therefore, the EA-927R (room temperature cure) adhesive would be used to bond the aluminum-graphite system which would be compared to the aluminum-graphite system with the elevated temperature cure adhesive. The EC-1614 (room temperature cure) adhesive would be used to bond the panel end fittings to the panel.

TABLE II

ADHESIVE SHEAR STRENGTH
(Double Lap Specimens)

MATERIAL COMBINATION	ADHESIVE	LAP LENGTH		WIDTH		AREA		2 X AREA		FAILURE LOAD		SHEAR STRESS	
		mm	(IN.)	mm	(IN.)	mm^2	$(IN.^2)$	mm^2	$(IN.^2)$	N	(lbf)	MN/m^2	(ksi)
Alum.-Alum.	AF-126	13.08	.515	25.17	.991	329.2	.510	658.4	1.02	26,466	5,950	40.22	5.833
		12.95	.510	25.45	1.002	329.6	.511	659.2	1.02	26,510	5,960	40.29	5.843
		12.83	.505	25.15	.990	322.7	.504	645.3	1.01	27,533	6,190	42.26	6.129
											AVG.	40.92	5.935
Alum.-Graphite	AF-126	12.70	.500	25.65	1.01	325.8	.505	651.5	1.01	19,171	4,310	29.42	4.267
		12.95	.510	25.40	1.00	328.9	.510	657.9	1.02	21,528	4,840	32.72	4.745
		12.70	.500	25.65	1.01	325.8	.505	651.5	1.01	19,660	4,420	30.17	4.376
											AVG.	30.77	4.463
Alum.-Glass	AF-126	12.70	.500	25.40	1.00	322.6	.500	645.2	1.00	20,906	4,700	32.41	4.700
		12.70	.500	25.40	1.00	322.6	.500	645.2	1.00	20,238	4,550	31.37	4.550
		12.95	.510	25.65	1.01	332.2	.515	664.3	1.03	22,151	4,980	33.34	4.835
											AVG.	32.37	4.695
Alum.-Graphite	EA-927R	12.45	.490	25.65	1.01	319.3	.495	638.7	0.99	12,365	2,780	19.36	2.808
		12.32	.485	25.65	1.01	316.0	.490	632.0	0.98	12,855	2,890	20.33	2.949
		12.19	.480	25.65	1.01	312.7	.485	625.3	0.97	11,787	2,650	18.84	2.732
											AVG.	19.51	2.830
Alum.-Graphite	EC-1614	13.21	.520	25.65	1.01	338.8	.525	677.7	1.05	13,833	3,110	20.42	2.962
		13.34	.525	25.40	1.00	338.8	.525	677.7	1.05	13,789	3,100	20.35	2.952
		12.95	.510	25.65	1.01	332.2	.515	664.3	1.03	12,499	2,810	18.81	2.728
											AVG.	19.86	2.881



NOTE: 1) All dimensions are millimeters and inches, respectively.

2) Graphite Composite - 6 plies thick

3) Glass Composite - 15 plies thick

4) Specimen width is 25.4 mm(1.0 in.)

FIGURE 2 DOUBLE LAP SHEAR SPECIMEN

COUPON STATIC TENSILE TESTS

Objective

The objective of this task was to conduct static tensile tests to obtain basic coupon data for composite-reinforced metal structure.

Approach

Combinations of graphite reinforced aluminum and glass reinforced aluminum coupon specimens bonded with elevated and room temperature cure adhesives were tested in static tension and compared to all aluminum coupon results. Strain gages were mounted on the aluminum portion of the specimens so that the load-strain data could be compared directly to the load-strain data for the all aluminum coupon specimens. Smooth specimens ($K_t = 1.0$) and specimens with a hole ($K_t > 1.0$) were tested and compared to evaluate the effects of holes on composite-reinforced metal structure.

Test Specimens

The specimens used to conduct the static tensile tests were as shown in Figure 3. The smooth tensile coupons were instrumented with one axial strain gage located on the longitudinal centerline at the minimum cross section. A stress concentration factor ($K_t > 1.0$) was obtained by drilling and reaming a 3.2 mm (.125 in.) diameter hole on the longitudinal centerline at the minimum width. These specimens were instrumented with a strain gage on either side of the hole at the minimum cross section on one aluminum surface only.

Sixteen static tensile coupon tests were conducted involving all aluminum, aluminum-graphite/epoxy, and aluminum-glass/epoxy with adhesives AF-126 and EA-927R. Table III presents the identification of the test specimens.

Testing and Results

The dimensions of each composite and metal thickness of each coupon specimen were measured at the minimum section and recorded before bonding the composite material to the aluminum and after bonding and machining. After recording the dimensions a tensile load was applied at a cross head travel rate of 1.27 mm/min. (0.05 in./min.) to obtain a load-strain curve through ultimate failure for each specimen. The plot of total load versus strain for each of the specimens, 1A through 16A, is presented in Figures 4 through 19. Each specimen critical cross section dimensions and failure load is presented in Table IV.

Discussion

The ultimate tensile strengths in Table IV were calculated using the total coupon area ($A_c + A_m$) minus the area of the hole. The strengths of the all-aluminum coupons were essentially the same. The strengths of the aluminum-graphite coupons with holes were about 7 percent less for the EA-927R adhesive and about 19 percent less for the AF-126 adhesive than coupons without holes. The strengths of the aluminum-glass coupons with holes were about 21 percent less than coupons without holes. The larger reduction in strengths for the AF-126 adhesive in the aluminum-graphite coupons could be due to residual thermal stresses.

Conclusions

The composite-metal structure shows to be more sensitive to static stress concentrations than all metal structure; however, a higher average ultimate tensile strength is obtained.

TABLE III

STATIC TENSILE COUPON IDENTIFICATION

SPEC. NO.	MATERIAL COMBINATION	NO. OF COMPOSITE PLIES	ADHESIVE	K_t
1A	All Aluminum	----	----	$K_t = 1.0$
2A	All Aluminum	----	----	$K_t = 1.0$
3A	Al.-Graphite	4	AF-126	$K_t = 1.0$
4A	Al.-Graphite	4	AF-126	$K_t = 1.0$
5A	Al.-Glass	3	AF-126	$K_t = 1.0$
6A	Al.-Glass	3	AF-126	$K_t = 1.0$
7A	Al.-Graphite	4	EA-927R	$K_t = 1.0$
8A	Al.-Graphite	4	EA-927R	$K_t = 1.0$
9A	All Aluminum	----	----	$K_t > 1.0$
10A	All Aluminum	----	----	$K_t > 1.0$
11A	Al.-Graphite	4	AF-126	$K_t > 1.0$
12A	Al.-Graphite	4	AF-126	$K_t > 1.0$
13A	Al.-Glass	3	AF-126	$K_t > 1.0$
14A	Al.-Glass	3	AF-126	$K_t > 1.0$
15A	Al.-Graphite	4	EA-927R	$K_t > 1.0$
16A	Al.-Graphite	4	EA-927R	$K_t > 1.0$

TABLE IV

STATIC TENSILE COUPON TEST DATA

Coupon Number	K_t	Material Combination	Coupon Width		Hole Dia.		Thickness					
							Total		Composite		Each Metal	
			mm	(in.)	mm	(in.)	mm	(in.)	mm	(in.)	mm	(in.)
1A	1.0	All Aluminum	12.80	.504	---	---	.973	.0383	---	---	---	---
2A	1.0	All Aluminum	12.67	.499	---	---	.983	.0387	---	---	---	---
3A	1.0	Alum.-Graphite	12.78	.503	---	---	2.090	.0823	.813	.032	.508	.020
4A	1.0	Alum.-Graphite	12.78	.503	---	---	2.042	.0804	.787	.031	.508	.020
5A	1.0	Alum.-Glass	12.40	.488	---	---	1.798	.0708	.584	.023	.495	.0195
6A	1.0	Alum.-Glass	12.78	.503	---	---	1.791	.0705	.584	.023	.495	.0195
7A	1.0	Alum.-Graphite	12.62	.497	---	---	2.276	.0896	.813	.032	.508	.020
8A	1.0	Alum.-Graphite	12.67	.499	---	---	2.205	.0868	.762	.030	.508	.020
9A	>1.0	All Aluminum	12.70	.500	3.165	.1246	.970	.0382	---	---	---	---
10A	>1.0	All Aluminum	12.65	.498	3.172	.1249	.973	.0383	---	---	---	---
11A	>1.0	Alum.-Graphite	12.78	.503	3.274	.1289	1.971	.0776	.737	.029	.508	.020
12A	>1.0	Alum.-Graphite	12.78	.503	3.266	.1286	2.009	.0791	.787	.031	.508	.020
13A	>1.0	Alum.-Glass	12.73	.501	3.233	.1273	1.808	.0712	.610	.024	.508	.020
14A	>1.0	Alum.-Glass	12.73	.501	3.208	.1263	1.819	.0716	.584	.023	.508	.020
15A	>1.0	Alum.-Graphite	12.73	.501	3.307	.1302	2.187	.0861	.813	.032	.508	.020
16A	>1.0	Alum.-Graphite	12.55	.494	3.302	.1300	2.258	.0889	.813	.032	.508	.020

TABLE IV

STATIC TENSILE COUPON TEST DATA (CONT.)

Coupon Number	K_t	Material Combination	Total Yield Load		Total Failing Load		Ultimate Tensile Strength	
			N	(lbf.)	N	(lbf.)	MN/m^2	(ksi)
1A	1.0	All Aluminum	7,117	1600	7,277	1636	584.7	84.8
2A	1.0	All Aluminum	6,761	1520	7,295	1640	581.2	84.3
3A	1.0	Alum.-Graphite	---	---	22,685	5100	849.5	123.2
4A	1.0	Alum.-Graphite	---	---	21,261	4780	815.0	118.2
5A	1.0	Alum.-Glass	10,008	2250	22,262	5005	999.1	144.9
6A	1.0	Alum.-Glass	10,052	2260	22,685	5100	991.5	143.8
7A	1.0	Alum.-Graphite	---	---	22,240	5000	774.3	112.3
8A	1.0	Alum.-Graphite	---	---	20,194	4540	722.6	104.8
9A	>1.0	All Aluminum	5,284	1188	5,444	1224	588.8	85.4
10A	>1.0	All Aluminum	4,750	1068	5,231	1176	567.5	82.3
11A	>1.0	Alum.-Graphite	---	---	12,365	2780	660.5	95.8
12A	>1.0	Alum.-Graphite	12,788	2875	13,077	2940	684.7	99.3
13A	>1.0	Alum.-Glass	7,473	1680	13,411	3015	781.2	113.3
14A	>1.0	Alum.-Glass	7,562	1700	13,566	3050	784.0	113.7
15A	>1.0	Alum.-Graphite	---	---	13,273	2984	644.7	93.5
16A	>1.0	Alum.-Graphite	15,390	3460	15,657	3520	750.2	108.8

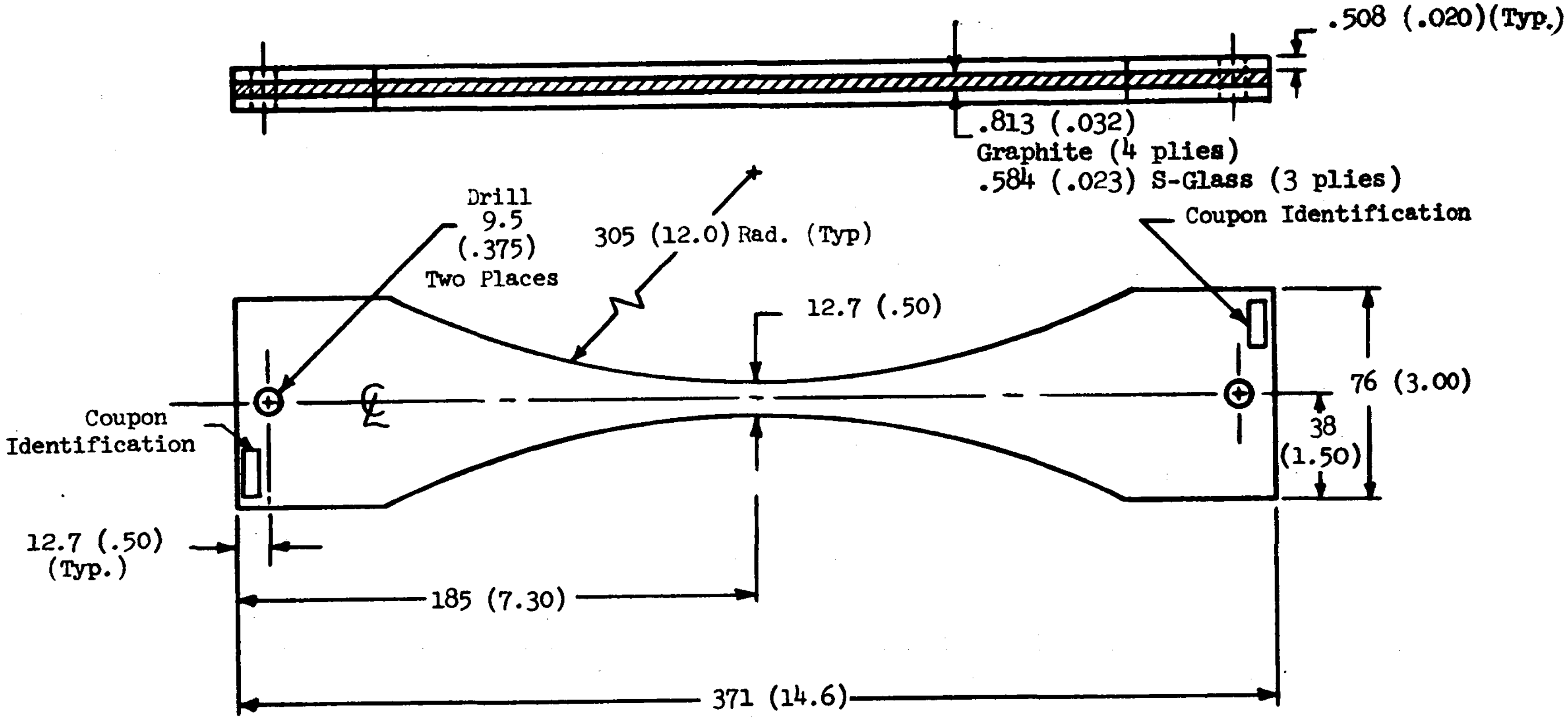


FIGURE 3 STATIC TENSILE COUPON SPECIMEN

(Dimensions in Millimeters and Inches Respectively)

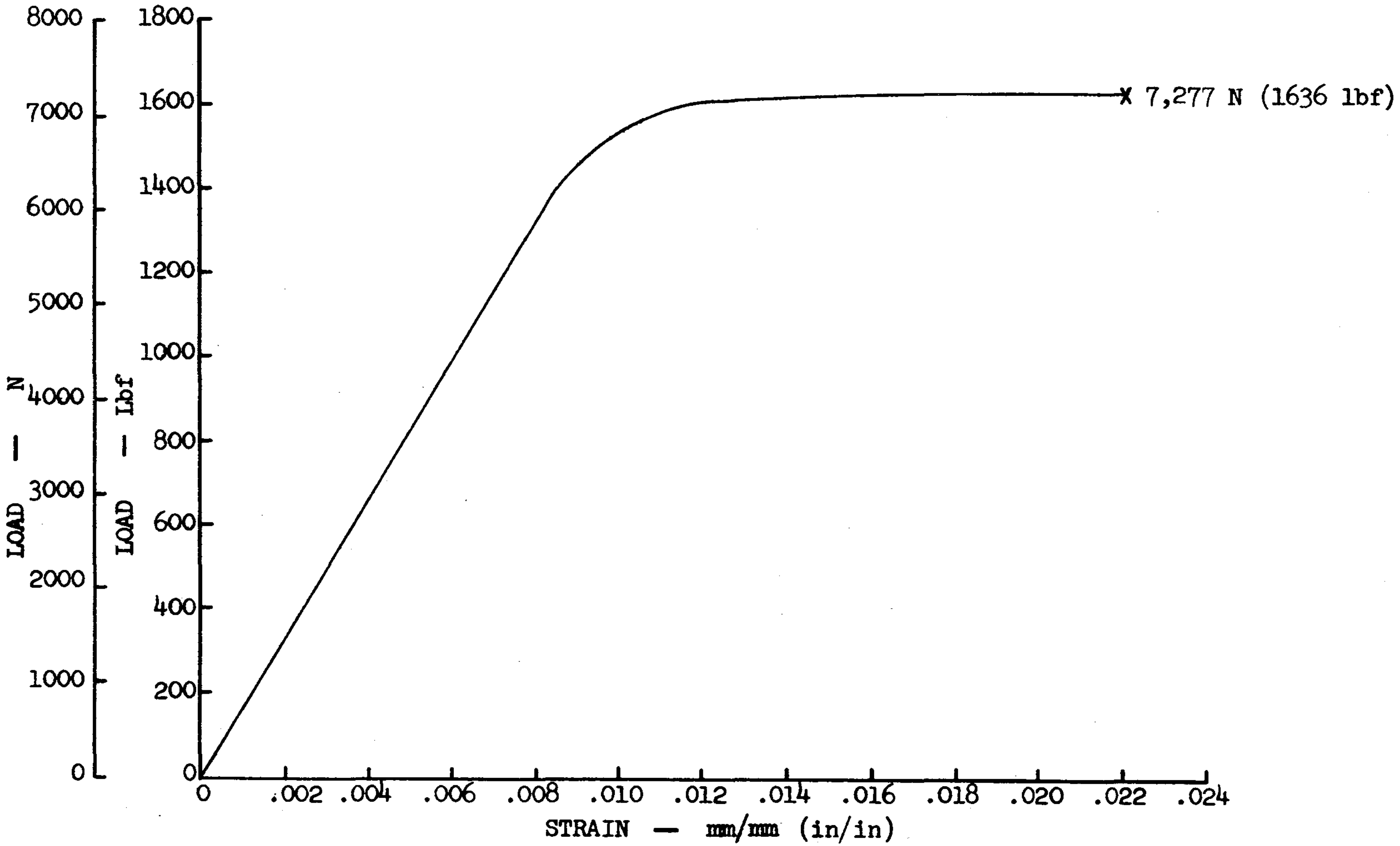


Figure 4 Load-Deflection Plot, Specimen 1A, All Aluminum

$K_t = 1.0$

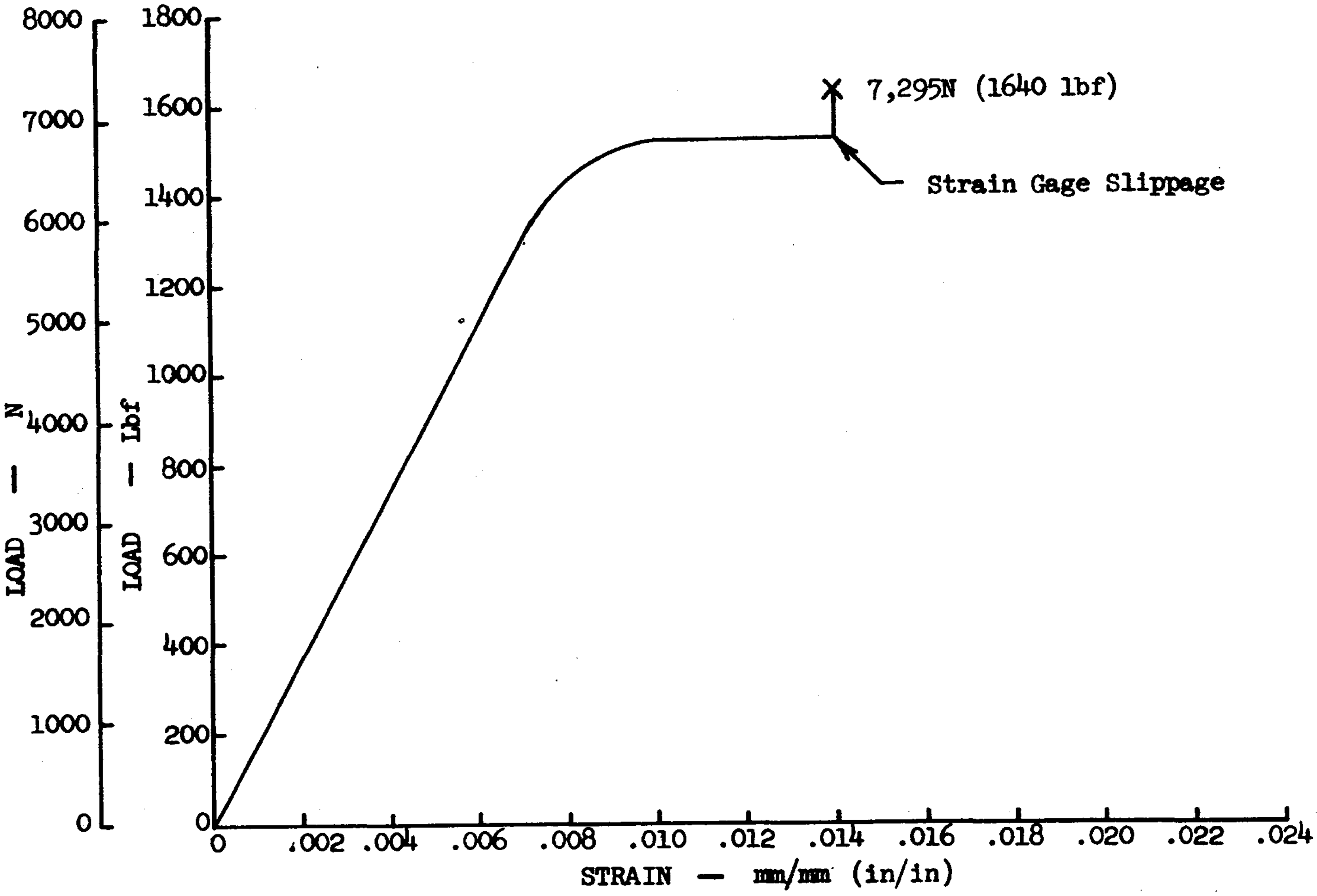


Figure 5 Load - Deflection Plot, Specimen 2A
All Aluminum $K_t = 1.0$

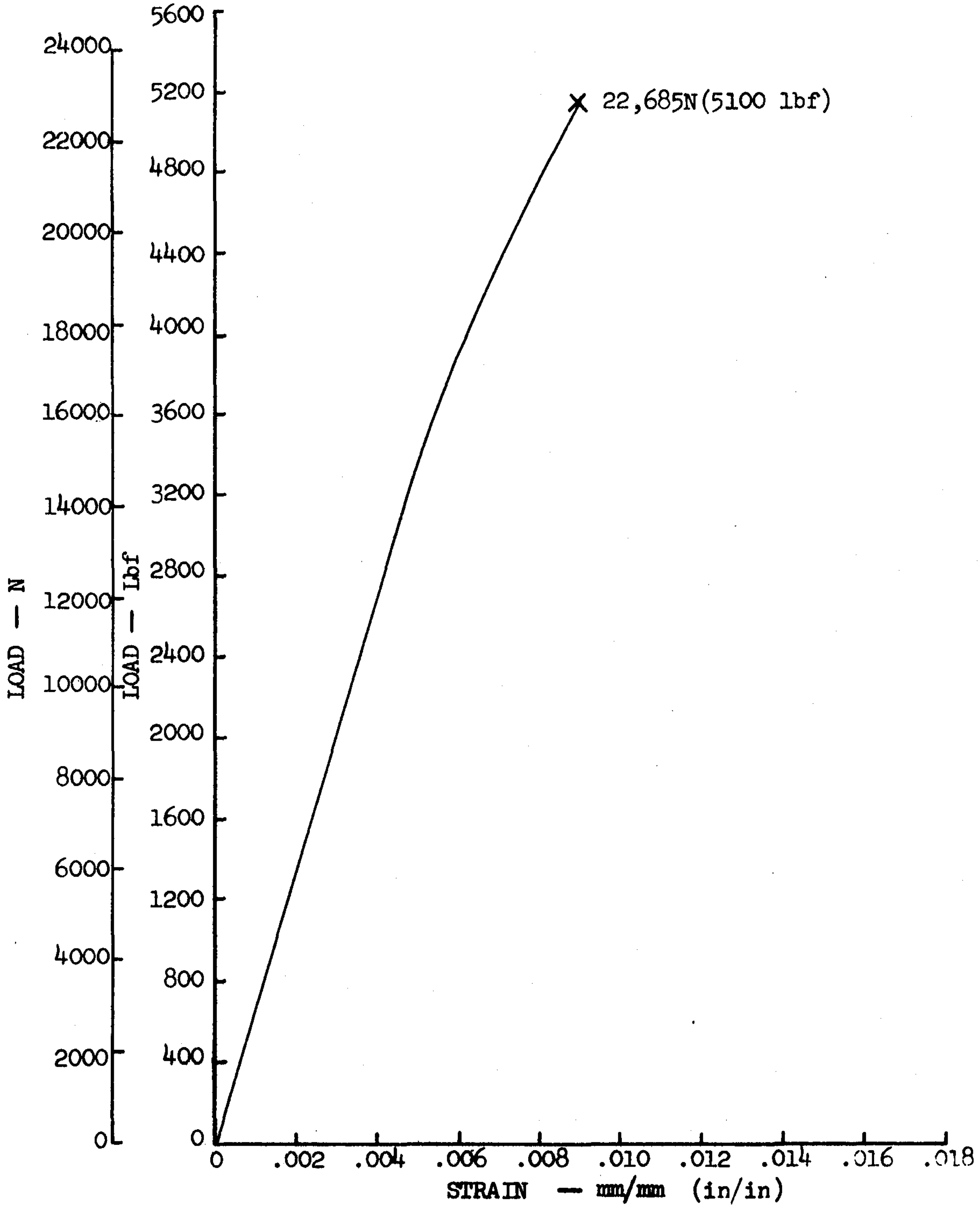


Figure 6 Load - Deflection Plot, Specimen 3A
Aluminum-Graphite, K_t = 1.0

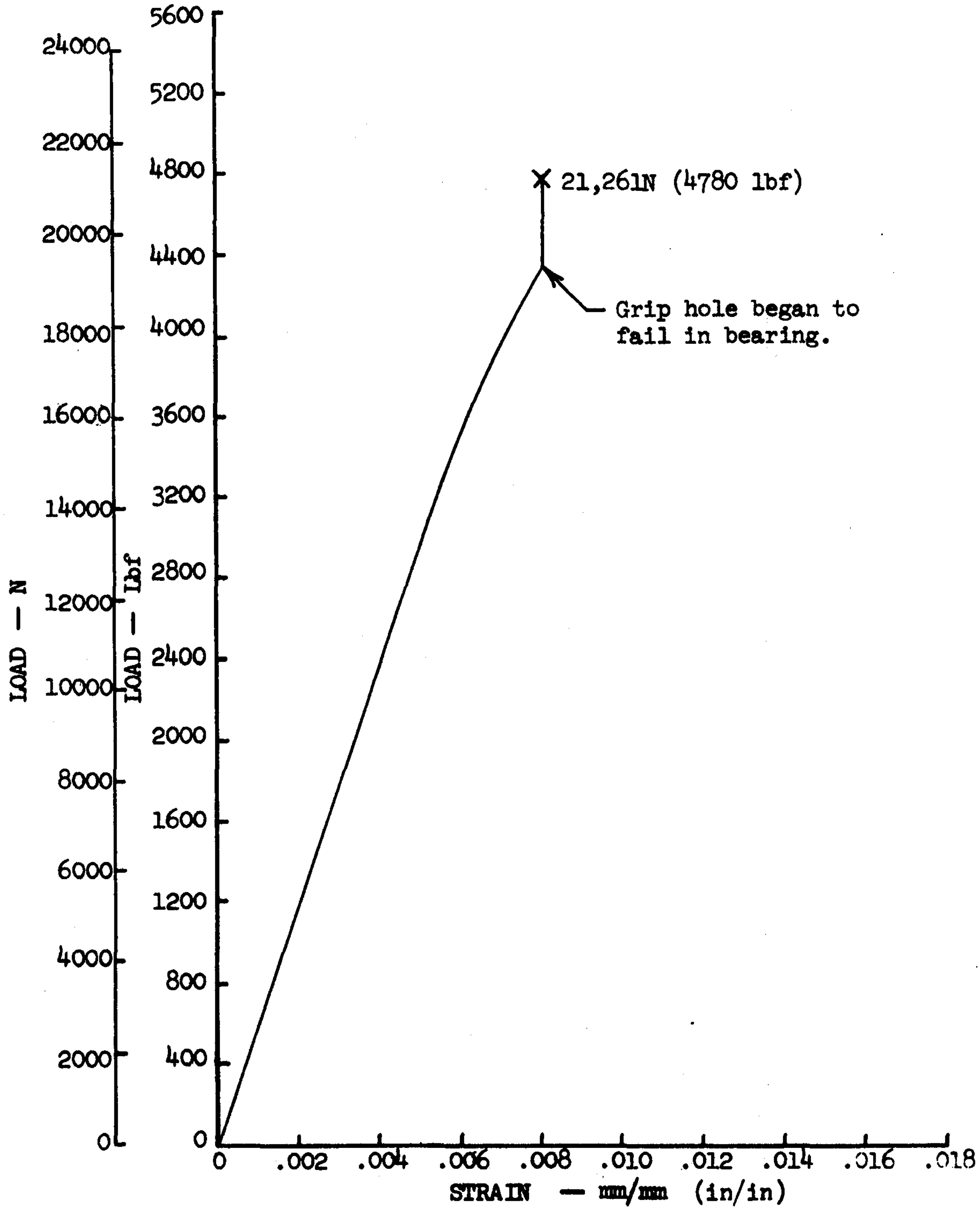


Figure 7 Load-Deflection Plot, Specimen 4A
Aluminum Graphite, $K_t = 1.0$

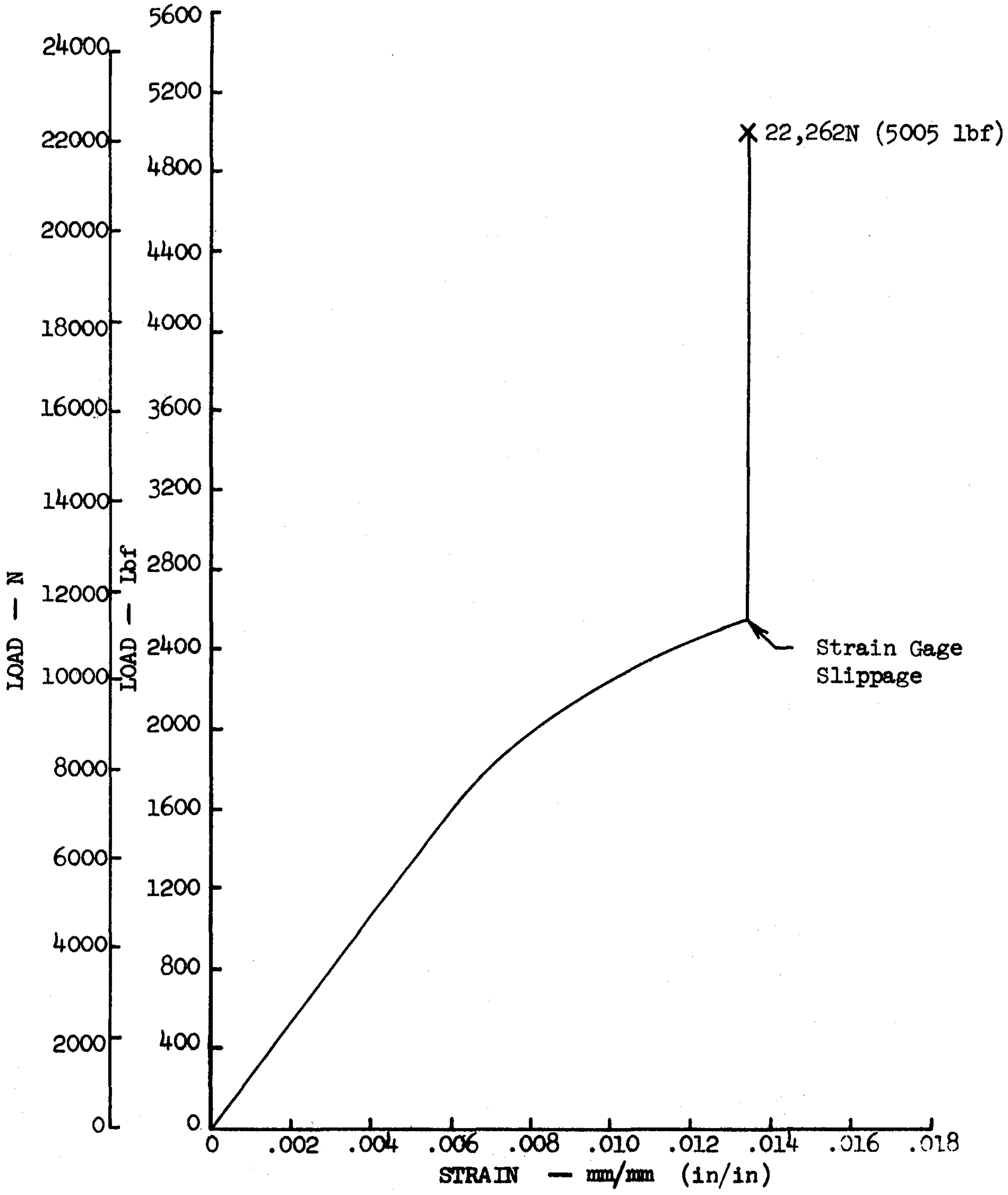


Figure 8 Load - Deflection Plot, Specimen 5A
Aluminum-Glass, K_t = 1.0

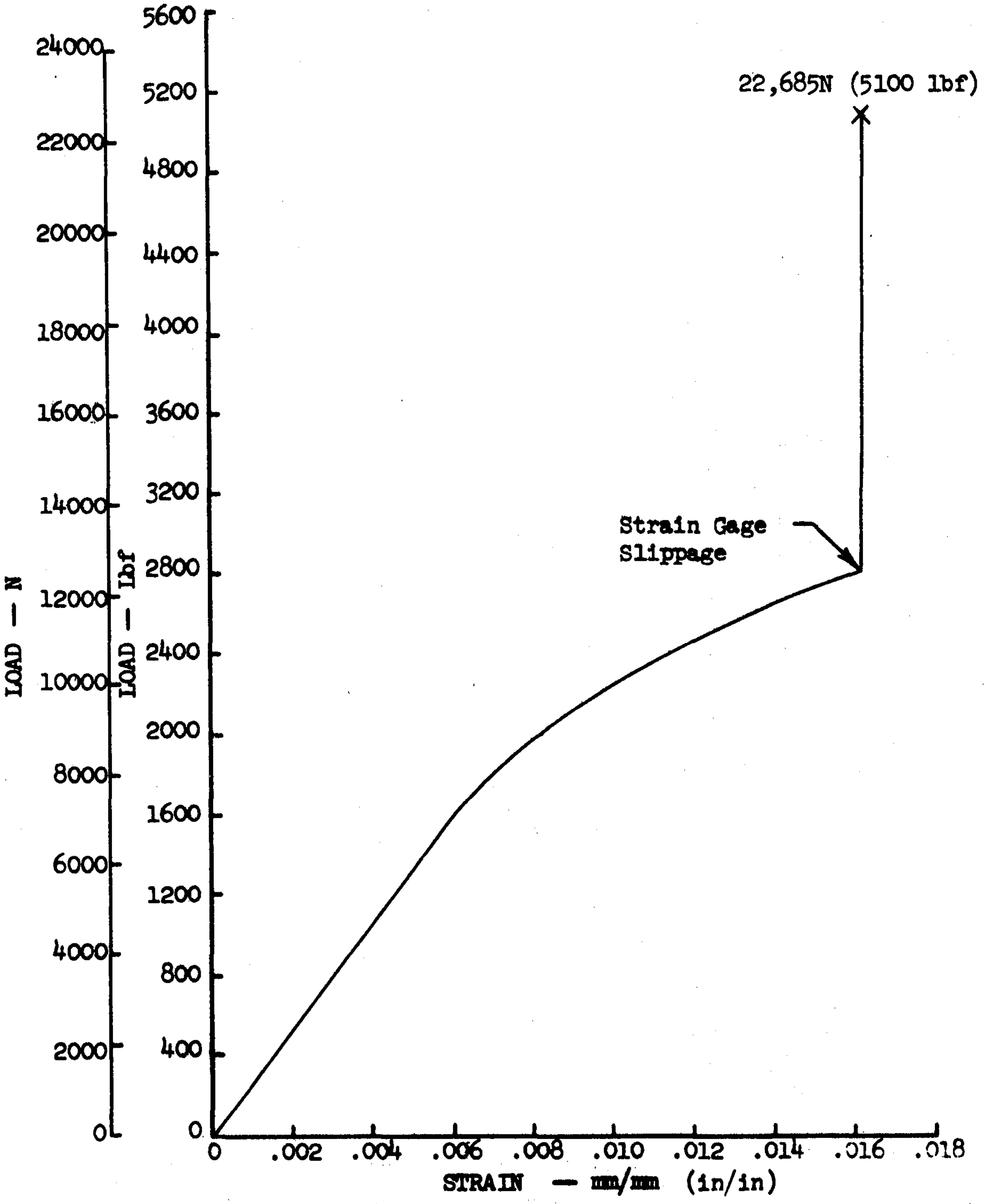


Figure 9 Load - Deflection Plot - Specimen 6A
Aluminum-Glass $K_t = 1.0$

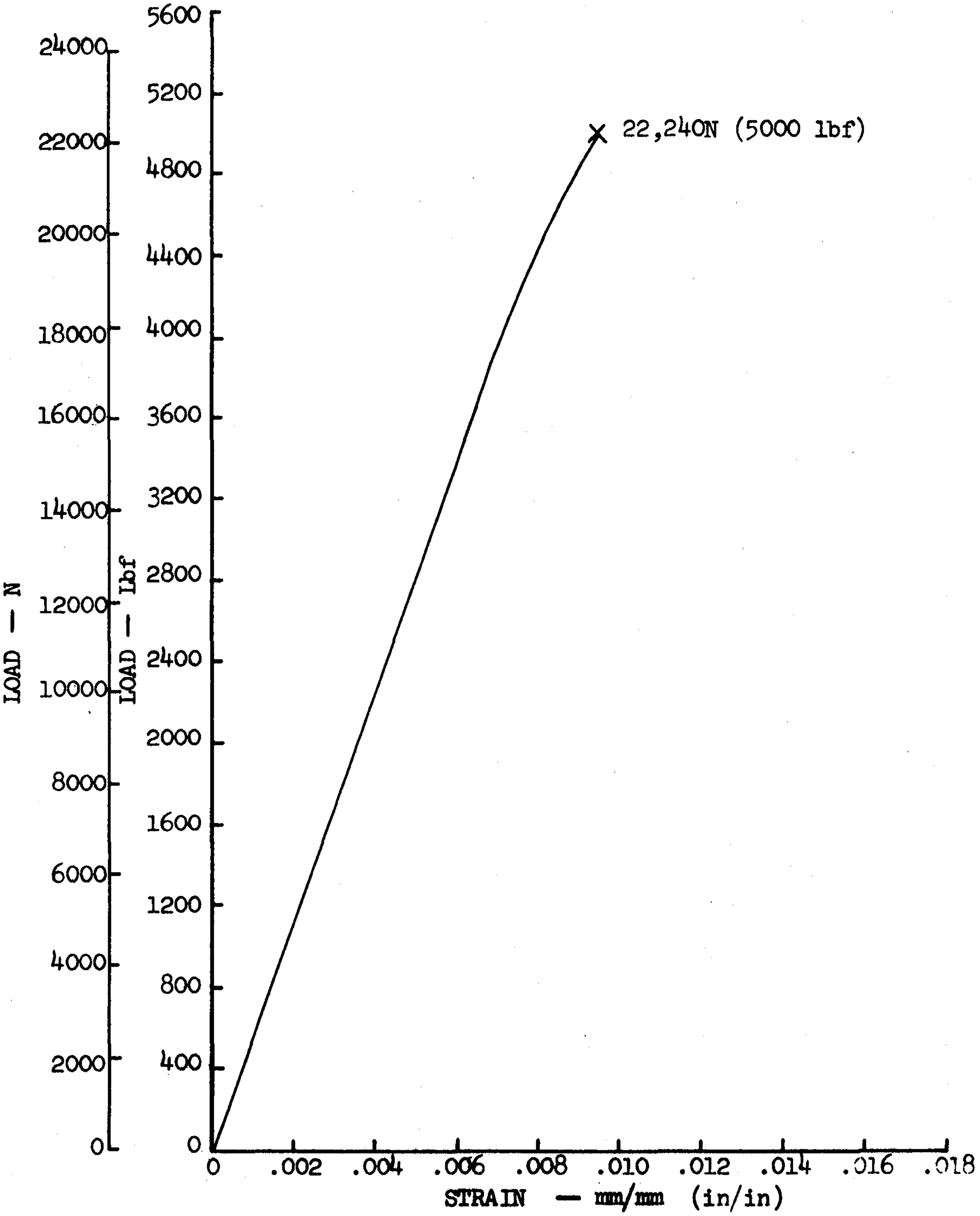


Figure 10 Load - Deflection, Specimen 7A
Aluminum-Graphite, $K_t = 1.0$

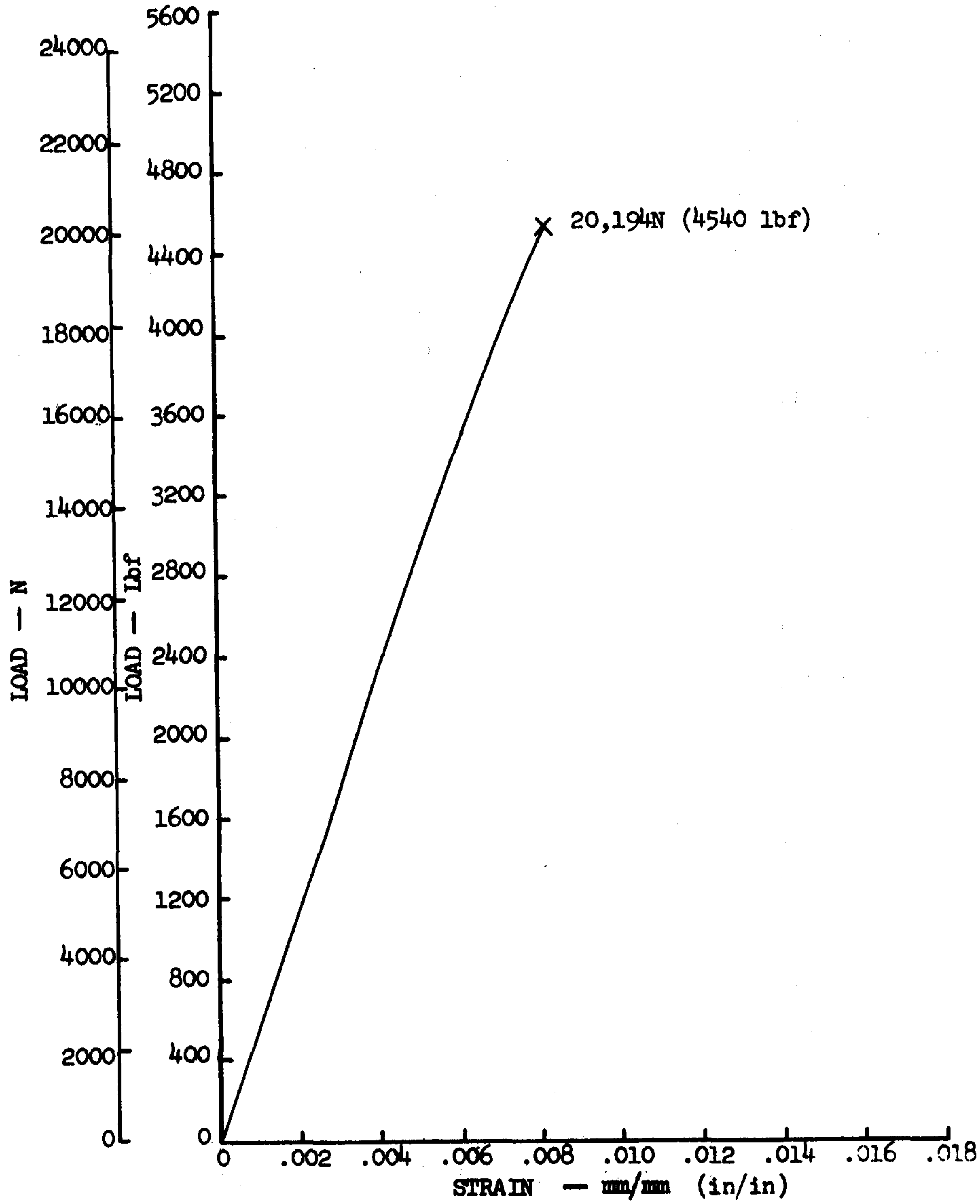


Figure 11 Load - Deflection Plot, Specimen 8A
Aluminum-Graphite, $K_t = 1.0$

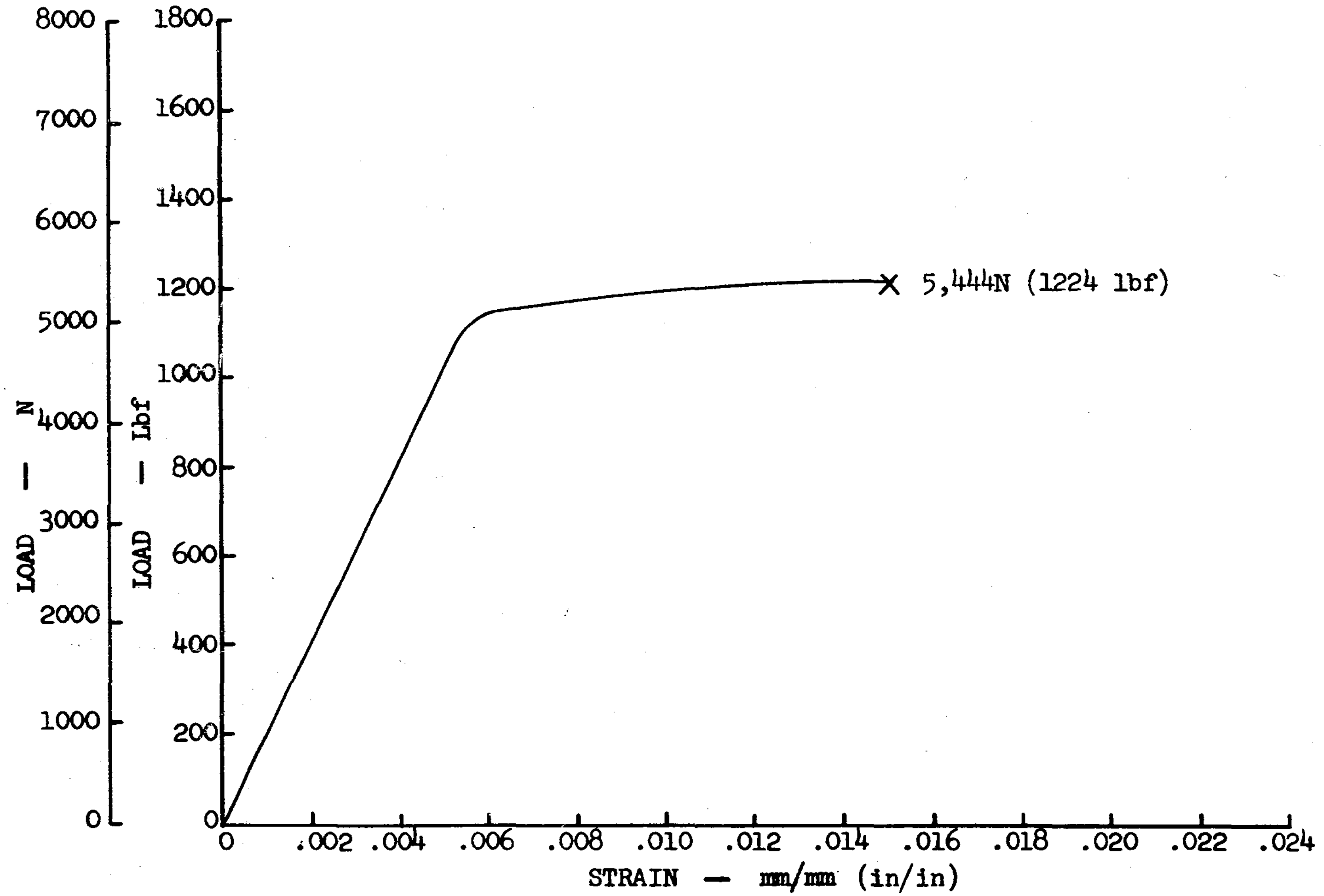


Figure 12 Load - Deflection Plot, Specimen 9A
All Aluminum, $K_t > 1.0$

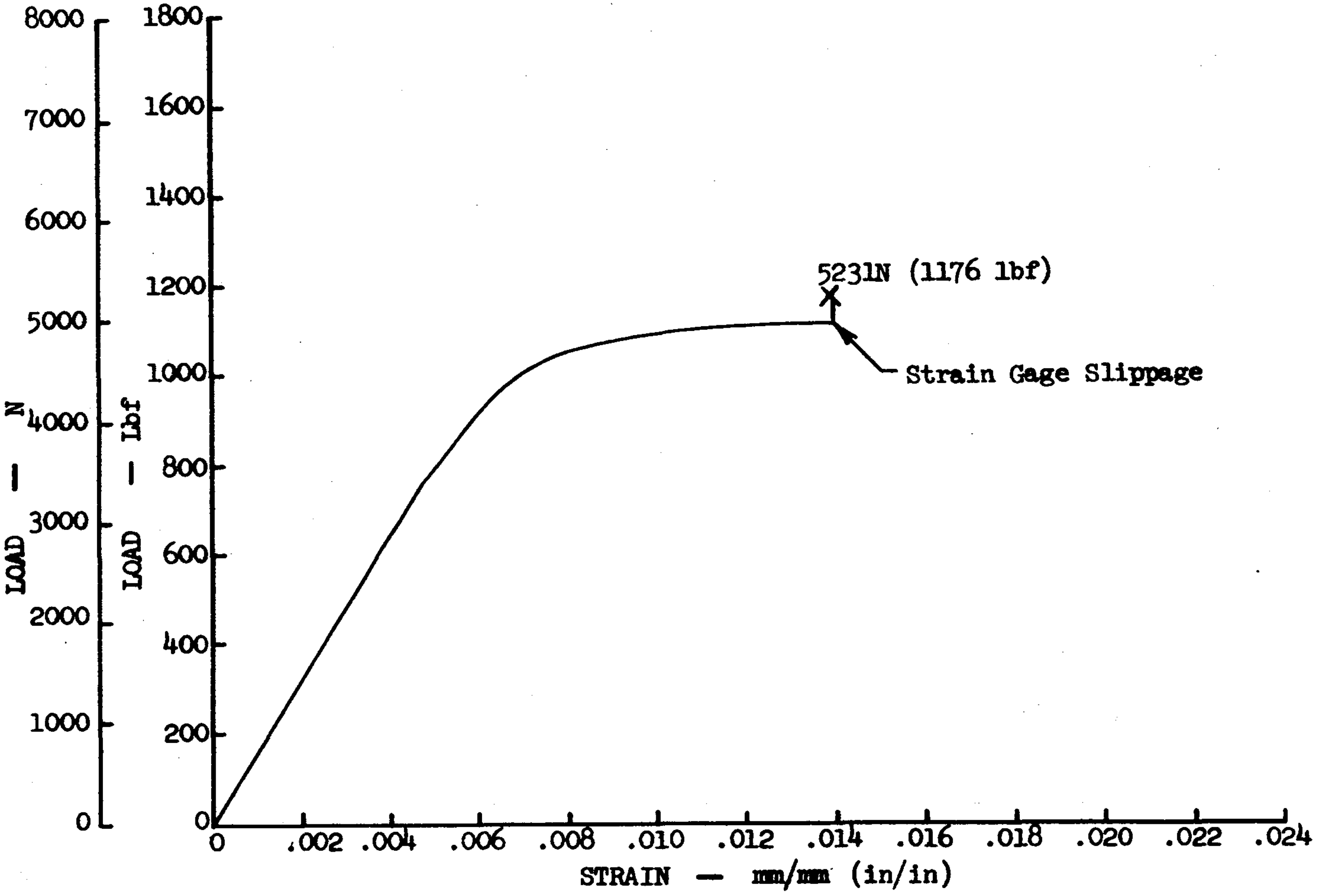


Figure 13 Load - Deflection Plot, Specimen 10A
All Aluminum, $K_t > 1.0$

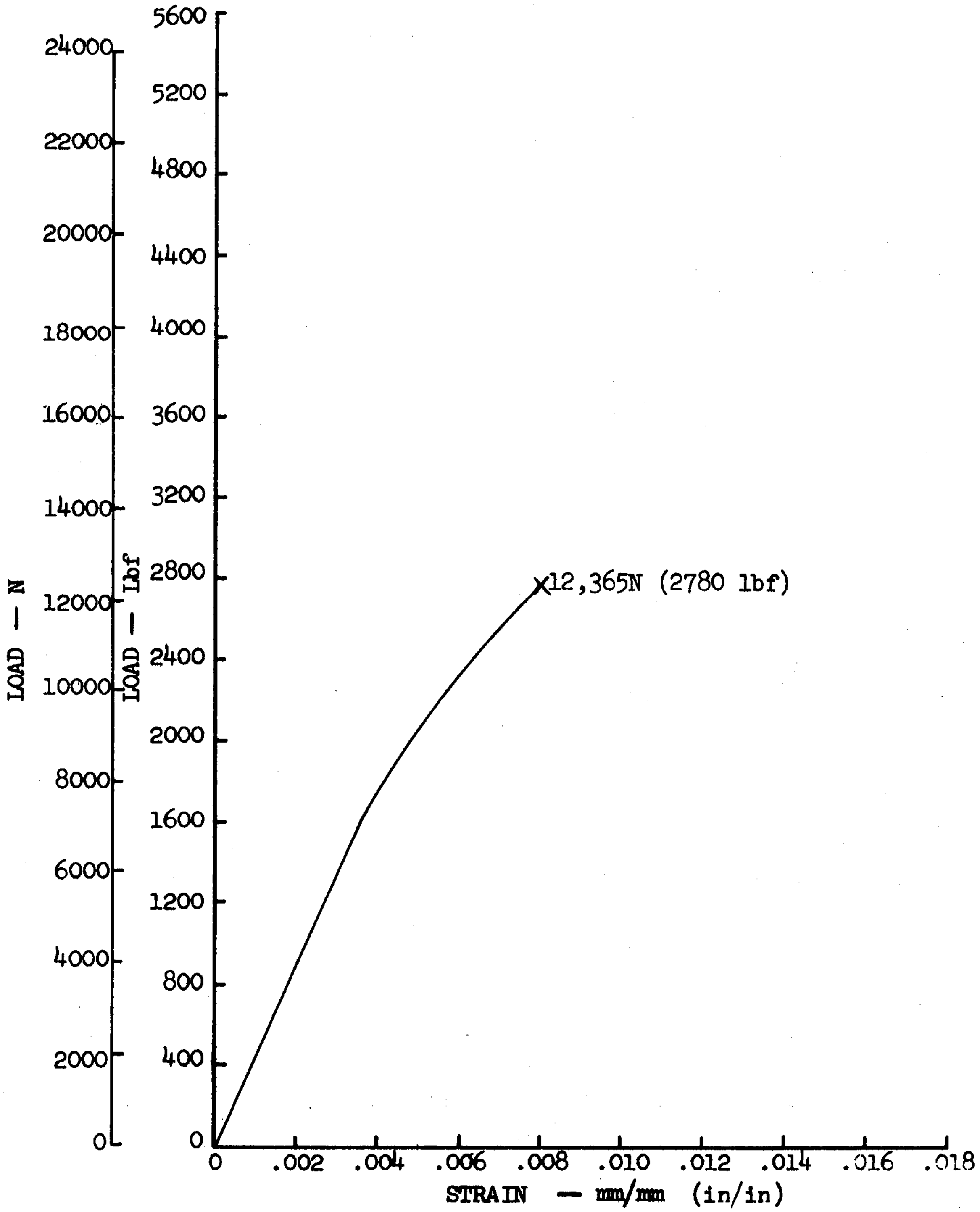


Figure 14 Load - Deflection Plot - Specimen 11A
Aluminum-Graphite, $K_t > 1.0$

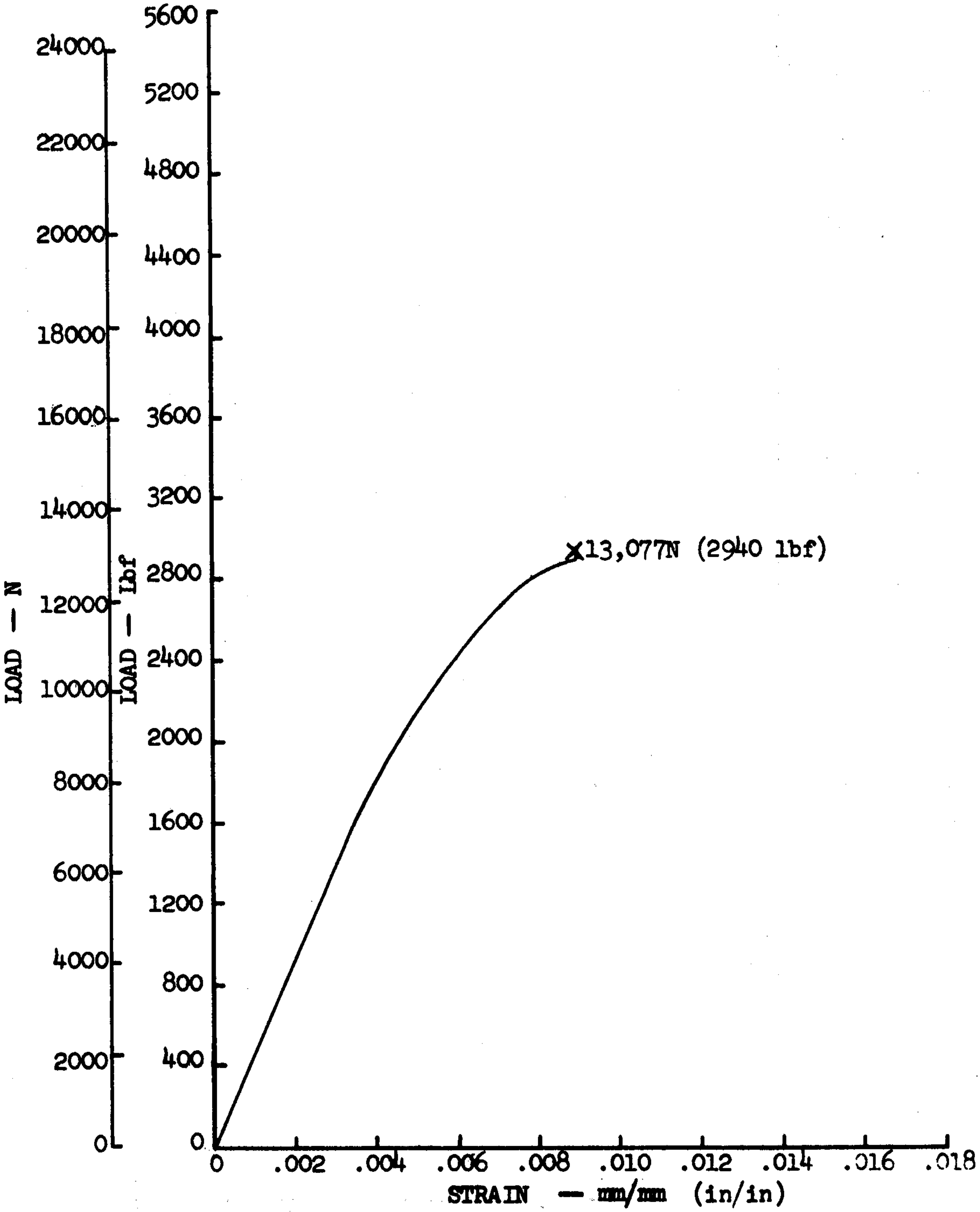


Figure 15 Load - Deflection Plot, Specimen 12A
Aluminum-Graphite, $K_t > 1.0$

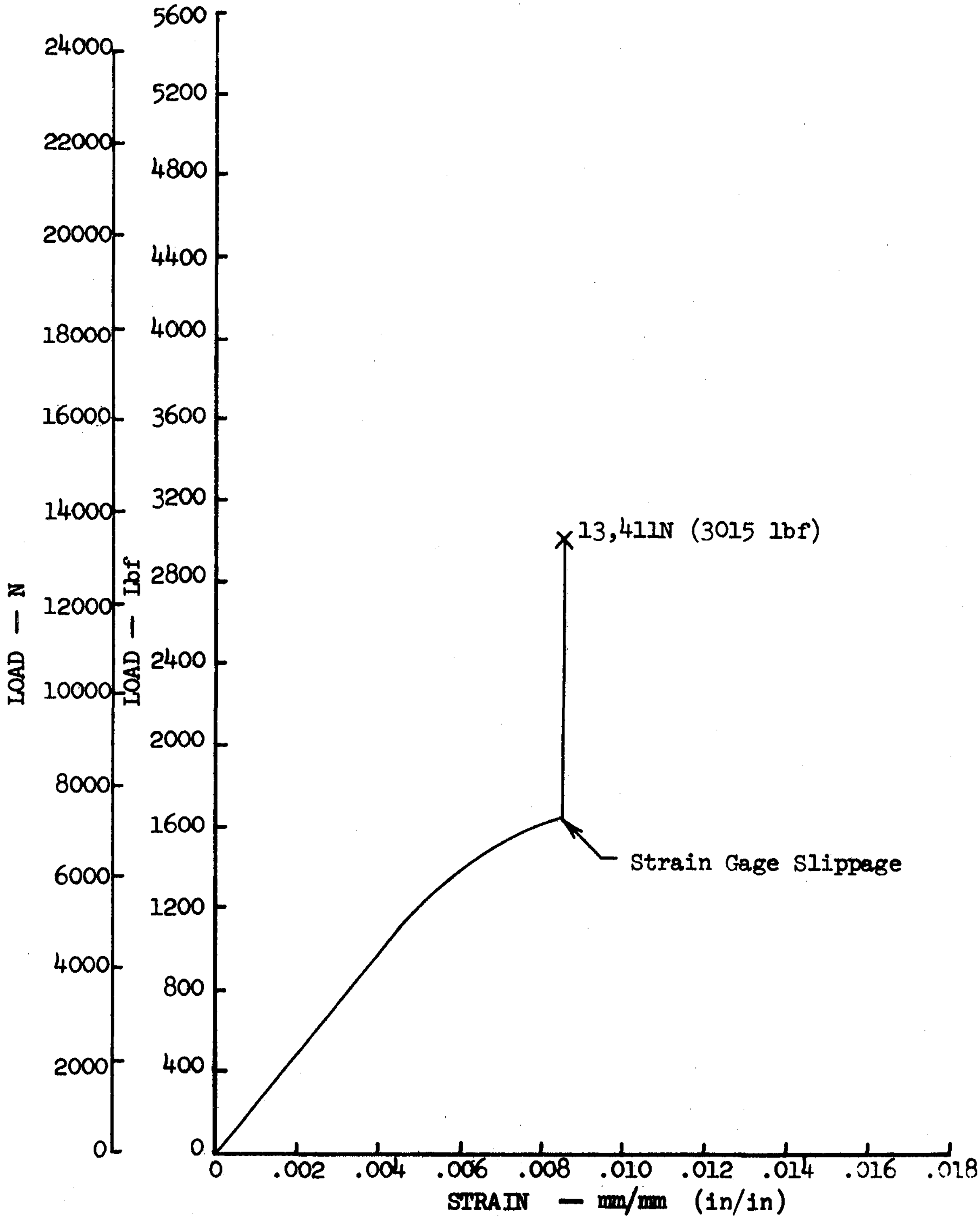


Figure 16 Load - Deflection Plot - Specimen 13A
Aluminum-Glass, $K_t > 1.0$

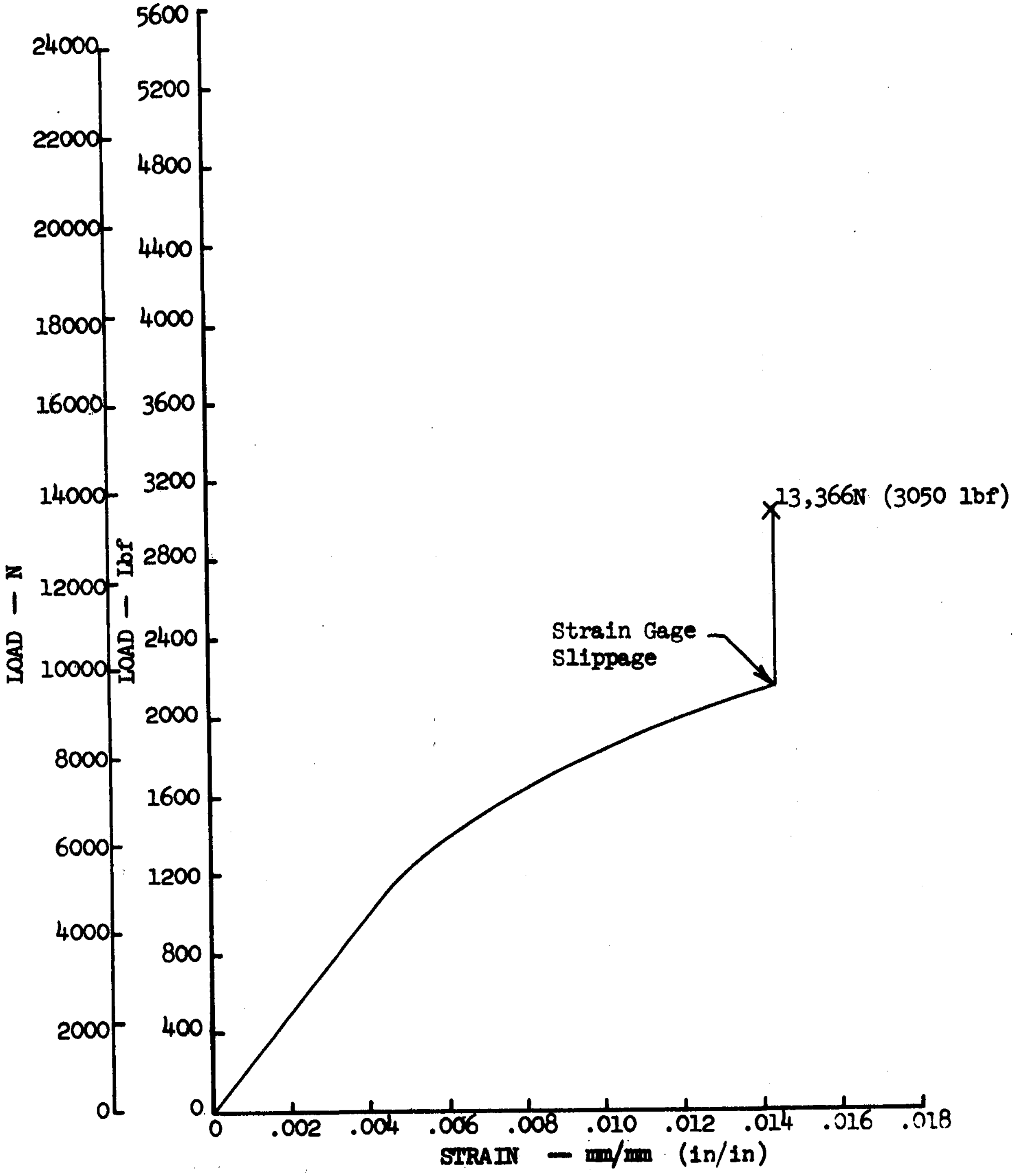


Figure 17 Load - Deflection Plot, Specimen 14A
Aluminum-Glass, $K_t > 1.0$

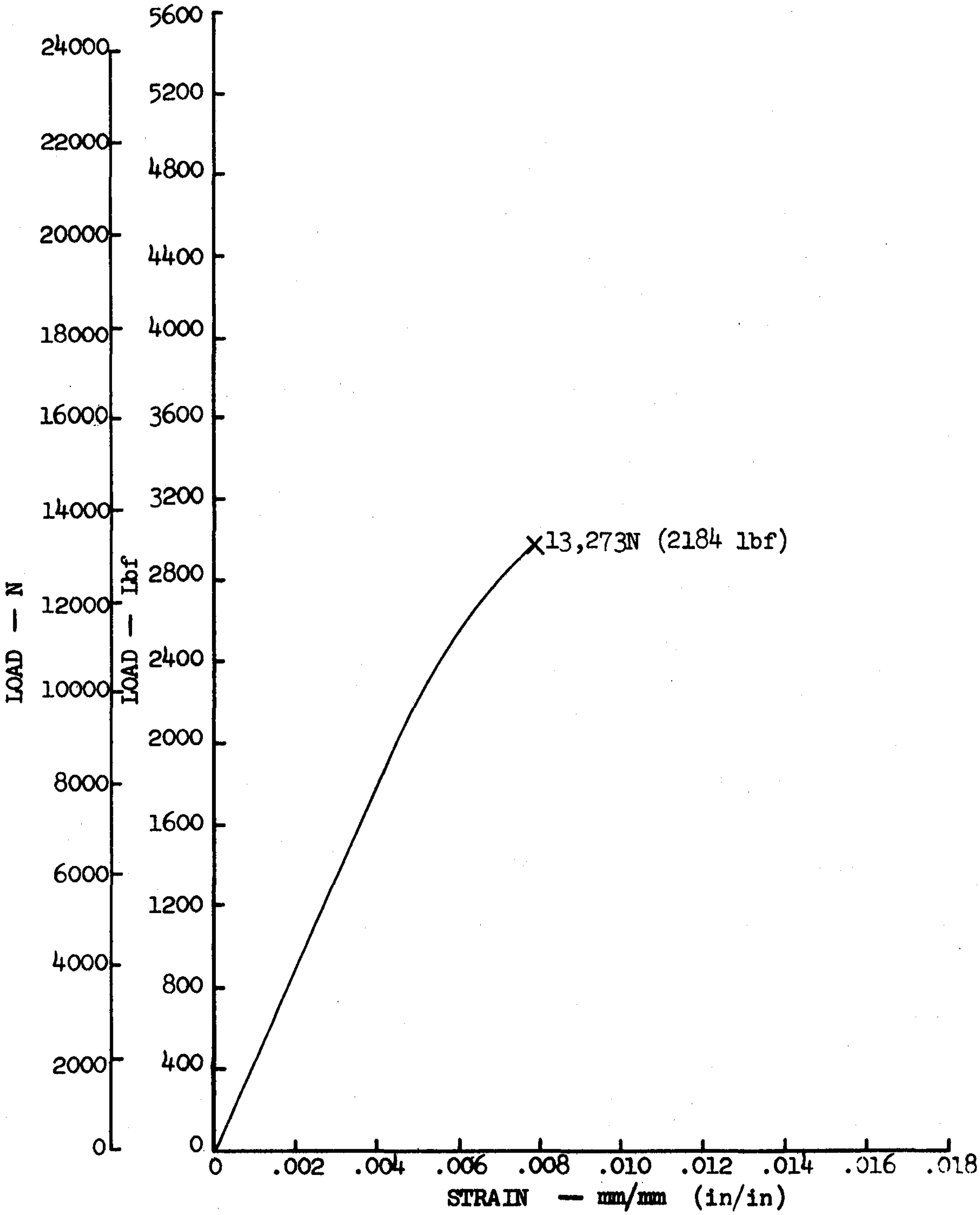


Figure 18 Load - Deflection Plot - Specimen 15A
Aluminum-Graphite, $K_t > 1.0$

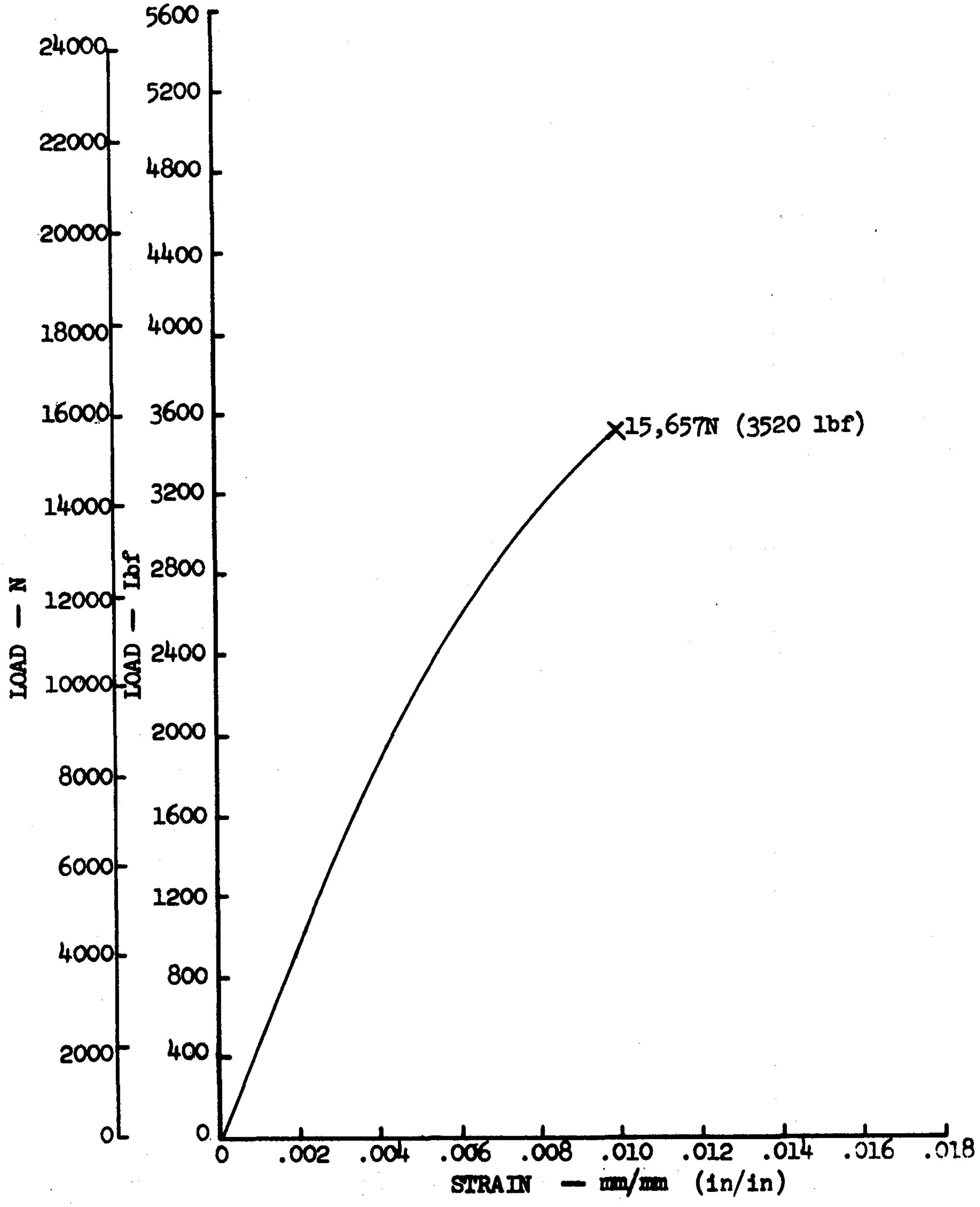


Figure 19 Load - Deflection Plot, Specimen 16A Aluminum-Graphite, $K_t > 1.0$

COUPON FATIGUE TESTS

Objective

The objective of this task was to conduct coupon fatigue tests to obtain basic fatigue behavior data and to provide data which would show the fail-safe characteristics of composite-reinforced metal structure.

Approach

Combinations of aluminum-graphite/epoxy and aluminum-glass/epoxy coupon fatigue specimens bonded with elevated and room temperature cure adhesives were tested in tension-tension fatigue and compared to all aluminum coupon fatigue results. Smooth specimens ($K_t = 1.0$) and specimens with a hole ($K_t > 1.0$) were tested and compared to evaluate the effects of holes on composite reinforced metal structure in fatigue loading.

Test Specimens

The specimens used in this evaluation were as shown in Figure 20. A stress concentration was obtained by drilling and reaming a 3.2 mm (.125 in.) diameter hole on the longitudinal centerline at the minimum width.

Sixty-six (66) fatigue coupon tests were conducted involving all aluminum, aluminum-graphite/epoxy, and aluminum-glass/epoxy with adhesives AF-126 and EA-927R. Table V presents the identification of the test specimens.

The control specimens were fabricated from 1.02 mm (0.040 in) thick 7075-T6 aluminum. The stiffness ratio was $\mu = 0.57$ for the aluminum-graphite system and $\mu = 0.29$ for the aluminum-glass system.

Testing and Results

The dimensions of each composite and metal thickness of each coupon specimen were measured at the minimum section and recorded before bonding the composite materials to the aluminum and after bonding and machining. After recording the dimensions the specimens were fatigue cycled in axial tension-tension loading at the load ratio of R = 0.10 and a frequency of 30 Hz (1800 cpm) until metal and composite failure. Each specimen cross section dimensions, cyclic load, cycles at time of metal failure and cycles at time of composite failure after metal failure, is given in Table VI. The gross stress in the metal and composite materials was calculated in terms of the total applied

load using equations (2) and (3). Figures 21, 22, and 23 show f_{max} - N curves for the various composite-metal-adhesive systems examined. Each figure gives the results for the three particular composite-metal-adhesive system examined for K_t = 1.0 and $K_t > 1.0$. Figure 21 gives the results for the aluminum-graphite system with the AF-126 adhesive. Figure 22 gives the results for the aluminum-graphite system with the EA-927R adhesive, and Figure 23 gives the results for the aluminum-glass system with the AF-126 adhesive.

Discussion

The fatigue coupon tests were conducted to indicate the stress concentration effects and demonstrate the fail-safe characteristics of composite-reinforced metal structure. The solid and dashed lines at the bottom of Figures 20, 21 and 22 are conventional fatigue curves for 7075-T6 aluminum (K_t = 1.0 and K_t = 2.4, respectively). The solid and dashed lines at the top of the figures indicate trend lines of the composite material failures (K_t = 1.0 and $K_t > 1.0$, respectively) following metal failures.

The value of stress concentration for all metal coupon specimens may be determined by geometry (ref. 3). For a 3.2 mm (0.125 in.) diameter hole in a 12.7 mm (0.50 in.) wide cross section the stress concentration value (K_t) is 2.4. Figures 21, 22 and 23 indicate that this K_t value also exists for the composite-metal coupons since the metal failures of the composite-metal coupons occur along the conventional all metal fatigue curves.

A particular total load applied to the composite-metal system is distributed to each material according to the stiffness ratio (μ) of the system. The maximum cyclic stress applied to the metal is shown in Figures 21, 22, and 23 until the metal fails. At that time the total load is carried by the composite alone; therefore, the composite stress level is increased significantly. At this stress level the composite continues to cycle until failure occurs. Thus a particular load can be carried by the system after the metal has failed demonstrating a fail-safe concept.

The extended life and weight savings of a composite-metal system over the all metal system can be obtained from the coupon fatigue test data. The stress in the metal of a composite-metal system can be determined by:

$$f_m = \frac{P_m}{A_m} = \frac{(1-\mu)\,P_t}{A_m} \tag{12}$$

The amount of metal in an all metal system needed to carry the same total load at the same stress level is

$$A_{am} = \frac{P_t}{f_m} \tag{13}$$

Substituting (12) into (13) yields the amount of metal saved in a composite-metal system over an all metal system, i.e.,

$$A_m = (1-\mu)A_{am} \tag{14}$$

Adding the area of the composite, the percent weight savings can be determined by

$$\%\ \text{Weight Saved} = \frac{Wt_{am} - Wt_{c-m}}{Wt_{am}} \times 100 \tag{15}$$

The percent of life extension of the composite-metal system over the all metal system can be determined by comparing the additional cycles of the composite after metal failure to the number of cycles of the initial failure of the metal, i.e.,

$$\%\ \text{Life Extension} = \frac{N_c}{N_m} \times 100 \tag{16}$$

Using the data in Table VI and equations (15) and (16), the percent weight savings and minimum life extension for the aluminum-graphite and aluminum-glass systems can be determined. Table VII presents a summary of these results.

Conclusions

The results of the test data of the composite-metal coupons indicate that the composite-reinforced metal structure is an effective fail-safe concept in terms of extended life and reduced weight. Table VII shows that the composite-metal system provides extended life for the same or less weight as the all metal system.

The fatigue coupon data also indicates that the stress concentration in the metal of the composite-metal system is approximately the same as in an all metal system. The stress concentration effects show a lesser degree of change in the fail-safeness in the aluminum-graphite system than in the aluminum-glass system. Also the use of the AF-126 adhesive (elevated temperature cure) or the EA-927R adhesive (room temperature cure) to bond the aluminum-graphite materials together produced no significant difference in the fatigue characteristics of the system.

TABLE V

FATIGUE COUPON IDENTIFICATION

Spec. No.	No. of Composite Plies	Material Combination	Adhesive	Kt
1B	----	All Aluminum	-----	1.0
2B	----	All Aluminum	-----	1.0
3B	----	All Aluminum	-----	1.0
4B	4	Alum.-Graphite	AF-126	1.0
5B	4	Alum.-Graphite	AF-126	1.0
6B	4	Alum.-Graphite	AF-126	1.0
7B	4	Alum.-Graphite	AF-126	1.0
8B	4	Alum.-Graphite	AF-126	1.0
9B	4	Alum.-Graphite	AF-126	1.0
10B	4	Alum.-Graphite	AF-126	1.0
11B	4	Alum.-Graphite	AF-126	1.0
12B	4	Alum.-Graphite	AF-126	1.0
13B	4	Alum.-Graphite	AF-126	1.0
14B	3	Alum.-Glass	AF-126	1.0
15B	3	Alum.-Glass	AF-126	1.0
16B	3	Alum.-Glass	AF-126	1.0
17B	3	Alum.-Glass	AF-126	1.0
18B	3	Alum.-Glass	AF-126	1.0
19B	3	Alum.-Glass	AF-126	1.0
20B	3	Alum.-Glass	AF-126	1.0
21B	3	Alum.-Glass	AF-126	1.0
22B	3	Alum.-Glass	AF-126	1.0
23B	3	Alum.-Glass	AF-126	1.0
24B	4	Alum.-Graphite	EA-927R	1.0
25B	4	Alum.-Graphite	EA-927R	1.0
26B	4	Alum.-Graphite	EA-927R	1.0
27B	4	Alum.-Graphite	EA-927R	1.0
28B	4	Alum.-Graphite	EA-927R	1.0
29B	4	Alum.-Graphite	EA-927R	1.0
30B	4	Alum.-Graphite	EA-927R	1.0
31B	4	Alum.-Graphite	EA-927R	1.0
32B	4	Alum.-Graphite	EA-927R	1.0
33B	4	Alum.-Graphite	EA-927R	1.0

TABLE V (Continued)

FATIGUE COUPON IDENTIFICATION

Spec. No.	No. of Composite Plies	Material Combination	Adhesive	Kt
34B	----	All Aluminum	-----	> 1.0
35B	----	All Aluminum	-----	> 1.0
36B	----	All Aluminum	-----	> 1.0
37B	4	Alum.-Graphite	AF-126	> 1.0
38B	4	Alum.-Graphite	AF-126	> 1.0
39B	4	Alum.-Graphite	AF-126	> 1.0
40B	4	Alum.-Graphite	AF-126	> 1.0
41B	4	Alum.-Graphite	AF-126	> 1.0
42B	4	Alum.-Graphite	AF-126	> 1.0
43B	4	Alum.-Graphite	AF-126	> 1.0
44B	4	Alum.-Graphite	AF-126	> 1.0
45B	4	Alum.-Graphite	AF-126	> 1.0
46B	4	Alum.-Graphite	AF-126	> 1.0
47B	3	Alum.-Glass	AF-126	> 1.0
48B	3	Alum.-Glass	AF-126	> 1.0
49B	3	Alum.-Glass	AF-126	> 1.0
50B	3	Alum.-Glass	AF-126	> 1.0
51B	3	Alum.-Glass	AF-126	> 1.0
52B	3	Alum.-Glass	AF-126	> 1.0
53B	3	Alum.-Glass	AF-126	> 1.0
54B	3	Alum.-Glass	AF-126	> 1.0
55B	3	Alum.-Glass	AF-126	> 1.0
56B	3	Alum.-Glass	AF-126	> 1.0
57B	4	Alum.-Graphite	EA-927R	> 1.0
58B	4	Alum.-Graphite	EA-927R	> 1.0
59B	4	Alum.-Graphite	EA-927R	> 1.0
60B	4	Alum.-Graphite	EA-927R	> 1.0
61B	4	Alum.-Graphite	EA-927R	> 1.0
62B	4	Alum.-Graphite	EA-927R	> 1.0
63B	4	Alum.-Graphite	EA-927R	> 1.0
64B	4	Alum.-Graphite	EA-927R	> 1.0
65B	4	Alum.-Graphite	EA-927R	> 1.0
66B	4	Alum.-Graphite	EA-927R	> 1.0

TABLE VI
FATIGUE COUPON TEST DATA

SPEC. NO.	COUPON WIDTH		HOLE DIAMETER		THICKNESS					
					TOTAL		EACH METAL		COMPOSITE	
	mm	(in.)	mm	(in.)	mm	(in.)	mm	(in.)	mm	(in.)
1B	12.65	.498	-	-	.980	.0386	-	-		
2B	12.65	.498	-	-	.980	.0386	-	-		
3B	12.83	.505	-	-	.980	.0386	-	-		
4B	12.80	.504	-	-	1.996	.0786	.508	.0200	.762	.030
5B	12.70	.500	-	-	1.989	.0783	.508	.0200	.762	.030
6B	12.75	.502	-	-	2.065	.0813	.508	.0200	.813	.032
7B	12.70	.500	-	-	2.057	.0810	.508	.0200	.813	.032
8B	12.75	.502	-	-	2.022	.0796	.508	.0200	.787	.031
9B	12.75	.502	-	-	2.035	.0801	.508	.0200	.813	.032
10B	12.75	.502	-	-	2.068	.0814	.508	.0200	.813	.032
11B	12.75	.502	-	-	2.065	.0813	.508	.0200	.787	.031
12B	12.70	.500	-	-	2.065	.0813	.508	.0200	.787	.031
13B	12.73	.501	-	-	2.098	.0826	.508	.0200	.813	.032
14B	12.65	.498	-	-	1.801	.0709	.495	.0195	.610	.024
15B	12.73	.501	-	-	1.798	.0708	.508	.0200	.610	.024
16B	12.75	.502	-	-	1.803	.0710	.508	.0200	.610	.024
17B	12.78	.503	-	-	1.793	.0706	.508	.0200	.584	.023
18B	12.75	.502	-	-	1.798	.0708	.495	.0195	.610	.024
19B	12.70	.500	-	-	1.803	.0710	.495	.0195	.584	.023
20B	12.67	.499	-	-	1.788	.0704	.495	.0195	.584	.023
21B	12.65	.498	-	-	1.791	.0705	.508	.0200	.584	.023
22B	12.65	.498	-	-	1.793	.0706	.508	.0200	.584	.023
23B	12.55	.494	-	-	1.793	.0706	.508	.0200	.584	.023
24B	12.73	.501	-	-	2.276	.0896	.508	.0200	.813	.032
25B	12.65	.498	-	-	2.268	.0893	.508	.0200	.787	.031
26B	12.73	.501	-	-	2.266	.0892	.495	.0195	.787	.031
27B	12.73	.501	-	-	2.319	.0913	.495	.0195	.838	.033
28B	12.75	.502	-	-	2.288	.0901	.495	.0195	.838	.033
29B	12.70	.500	-	-	2.220	.0874	.508	.0200	.787	.031
30B	12.65	.498	-	-	2.200	.0866	.508	.0200	.787	.031
31B	12.65	.498	-	-	2.189	.0862	.508	.0200	.838	.033
32B	12.67	.499	-	-	2.268	.0893	.508	.0200	.787	.031
33B	12.65	.498	-	-	2.301	.0906	.508	.0200	.787	.031

TABLE VI (Cont)
FATIGUE COUPON TEST DATA

SPEC. NO.	COUPON WIDTH		HOLE DIAMETER		THICKNESS					
					TOTAL		EACH METAL		COMPOSITE	
	mm	(in.)	mm	(in.)	mm	(in.)	mm	(in.)	mm	(in.)
34B	12.75	.502	3.188	.1255	.980	.0386	-	-	-	-
35B	12.73	.501	3.190	.1256	.980	.0386	-	-	-	-
36B	12.70	.500	3.180	.1252	.980	.0386	-	-	-	-
37B	12.73	.501	3.279	.1291	2.022	.0796	.508	.0200	.737	.029
38B	12.73	.501	3.185	.1254	2.042	.0804	.495	.0195	.813	.032
**39B	12.75	.502	3.264	.1285	2.035	.0801	.495	.0195	.813	.032
40B	12.78	.503	3.203	.1261	2.002	.0788	.495	.0195	.787	.031
**41B	12.70	.500	3.254	.1281	2.111	.0831	.495	.0195	.838	.033
42B	12.73	.501	3.233	.1273	2.073	.0816	.495	.0195	.838	.033
43B	12.73	.501	3.251	.1280	1.986	.0782	.495	.0195	.762	.030
44B	12.75	.502	3.208	.1263	2.042	.0804	.495	.0195	.838	.033
45B	12.75	.502	3.246	.1278	2.042	.0804	.495	.0195	.787	.031
46B	12.70	.500	3.269	.1287	2.047	.0806	.495	.0195	.787	.031
47B	12.65	.498	3.244	.1277	1.781	.0701	.508	.0200	.610	.024
48B	12.57	.495	3.152	.1241	1.796	.0707	.508	.0200	.610	.024
49B	12.67	.499	3.231	.1272	1.793	.0706	.508	.0200	.584	.023
50B	12.60	.496	3.200	.1260	1.798	.0708	.508	.0200	.610	.024
51B	12.75	.502	3.162	.1245	1.788	.0704	.495	.0195	.572	.0225
52B	12.60	.496	3.170	.1248	1.798	.0708	.495	.0195	.584	.023
53B	12.65	.498	3.208	.1263	1.801	.0709	.495	.0195	.584	.023
54B	12.67	.499	3.165	.1246	1.798	.0708	.495	.0195	.584	.023
55B	12.73	.501	3.203	.1261	1.798	.0708	.495	.0195	.584	.023
56B	12.75	.502	3.221	.1268	1.793	.0706	.495	.0195	.584	.023
57B	12.67	.499	3.218	.1267	2.253	.0887	.508	.0200	.813	.032
58B	12.60	.496	3.114	.1226	2.195	.0864	.495	.0195	.813	.032
59B	12.50	.492	3.231	.1272	2.228	.0877	.495	.0195	.787	.031
60B	12.70	.500	3.238	.1275	2.167	.0853	.495	.0195	.787	.031
61B	12.65	.498	3.241	.1276	2.240	.0882	.495	.0195	.813	.032
62B	12.62	.497	3.246	.1278	2.200	.0866	.495	.0195	.813	.032
63B	12.67	.499	3.231	.1272	2.184	.0860	.495	.0195	.813	.032
64B	12.73	.501	3.254	.1281	2.151	.0847	.508	.0200	.813	.032
65B	12.65	.498	3.266	.1286	2.149	.0846	.508	.0200	.813	.032
66B	12.67	.499	3.155	.1242	2.123	.0836	.508	.0200	.787	.031

**R = 0.17

TABLE VI (Cont)
FATIGUE COUPON TEST DATA

SPEC. NO.	MATERIAL COMBINATION	MAXIMUM TOTAL LOAD		METAL FAILURE		COMPOSITE FAILURE
		N	(lbf.)	1st SIDE (CYCLES)	2nd SIDE (CYCLES)	(CYCLES AFTER METAL FAILURE)
1B	All Aluminum	4,448	1000	35,000	-	-
2B	All Aluminum	4,448	1000	44,000	-	-
3B	All Aluminum	6,218	1398	12,000	-	-
4B	Alum-Graphite	12,454	2800	30,000	35,000	22,000
5B	Alum-Graphite	12,454	2800	17,000	17,000	13,000
6B	Alum-Graphite	13,700	3080	18,000	25,000	64,000
7B	Alum-Graphite	10,364	2330	55,000	69,000	6,229,000 *
8B	Alum-Graphite	10,364	2330	35,000	38,000	679,000
9B	Alum-Graphite	11,476	2580	28,000	33,000	19,000
10B	Alum-Graphite	8,896	2000	47,000	49,000	8,061,000 *
11B	Alum-Graphite	11,476	2580	33,000	33,000	141,000
12B	Alum-Graphite	11,476	2580	25,000	25,000	531,000
13B	Alum-Graphite	8,896	2000	35,000	36,000	7,560,000 *
14B	Alum-Glass	7,517	1690	11,000	14,000	11,000
15B	Alum-Glass	7,517	1690	19,000	21,000	9,000
16B	Alum-Glass	7,517	1690	12,000	13,000	9,000
17B	Alum-Glass	6,539	1470	20,000	24,000	16,000
18B	Alum-Glass	6,539	1470	28,000	34,000	18,000
19B	Alum-Glass	6,539	1470	26,000	26,000	12,000
20B	Alum-Glass	5,382	1210	35,000	55,000	46,000
21B	Alum-Glass	5,382	1210	65,000	68,000	34,000
22B	Alum-Glass	5,382	1210	58,000	74,000	40,000
23B	Alum-Glass	4,715	1060	66,000	98,000	86,000
24B	Alum-Graphite	12,454	2800	39,000	39,000	5,000
25B	Alum-Graphite	12,454	2800	37,000	39,000	3,000
26B	Alum-Graphite	11,053	2485	40,000	69,000	52,000
27B	Alum-Graphite	10,364	2330	95,000	95,000	2,101,000 *
28B	Alum-Graphite	11,031	2480	78,000	78,000	2,247,000 *
29B	Alum-Graphite	11,031	2480	49,000	72,000	62,000
30B	Alum-Graphite	8,896	2000	400,000	400,000	2,104,000 *
31B	Alum-Graphite	11,543	2595	24,000	30,000	7,000
32B	Alum-Graphite	10,675	2400	71,000	83,000	1,302,000 *
33B	Alum-Graphite	10,853	2440	41,000	53,000	83,000

* No Failure

TABLE VI (Cont)
FATIGUE COUPON TEST DATA

SPEC. NO.	MATERIAL COMBINATION	MAXIMUM TOTAL LOAD N	(lbf.)	METAL FAILURE 1st SIDE (CYCLES)	2nd SIDE (CYCLES)	COMPOSITE FAILURE (CYCLES AFTER METAL FAILURE)
34B	All Aluminum	2,068	465	50,000	-	-
35B	All Aluminum	2,068	465	39,000	-	-
36B	All Aluminum	1,543	347	1,041,000	-	-
37B	Alum-Graphite	5,782	1300	9,000	11,000	2,291,000 *
38B	Alum-Graphite	5,782	1300	13,000	14,000	2,486,000 *
**39B	Alum-Graphite	7,081	1592	10,000	10,000	28,000
40B	Alum-Graphite	4,804	1080	19,000	19,000	201,000 *
**41B	Alum-Graphite	7,081	1592	12,000	12,000	174,000
42B	Alum-Graphite	7,464	1678	8,000	8,000	147,000
43B	Alum-Graphite	6,561	1475	11,000	11,000	1,019,000
44B	Alum-Graphite	7,695	1730	8,000	8,000	2,482,000 *
45B	Alum-Graphite	7,473	1680	6,000	6,000	2,074,000 *
46B	Alum-Graphite	7,695	1730	6,000	6,000	1,569,000
47B	Alum-Glass	3,514	790	12,000	12,000	28,000
48B	Alum-Glass	3,514	790	11,000	11,000	33,000
49B	Alum-Glass	2,607	586	27,000	27,000	120,000
50B	Alum-Glass	3,002	675	20,000	20,000	53,000
51B	Alum-Glass	3,002	675	17,000	17,000	100,000
52B	Alum-Glass	2,607	586	32,000	33,000	82,000
53B	Alum-Glass	2,157	485	68,000	68,000	490,000
54B	Alum-Glass	2,157	485	50,000	50,000	329,000
55B	Alum-Glass	2,015	453	79,000	120,000	525,000
56B	Alum-Glass	3,941	886	11,000	11,000	15,000
57B	Alum-Graphite	5,782	1300	14,000	20,000	2,024,000 *
58B	Alum-Graphite	7,117	1600	9,000	15,000	2,354,000 *
59B	Alum-Graphite	7,784	1750	7,000	8,000	355,000
60B	Alum-Graphite	7,962	1790	8,000	10,000	74,000
61B	Alum-Graphite	8,162	1835	7,000	8,000	145,000
62B	Alum-Graphite	8,674	1950	4,000	7,000	37,000
63B	Alum-Graphite	8,718	1960	4,000	6,000	15,000
64B	Alum-Graphite	7,695	1730	7,000	11,000	901,000
65B	Alum-Graphite	7,895	1775	8,000	11,000	496,000
66B	Alum-Graphite	7,748	1742	7,000	8,000	246,000

**R = 0.17
* No Failure

TABLE VII

SUMMARY OF COUPON FATIGUE TESTS

COUPON MATERIAL COMBINATIONS	$K_t = 1.0$		$K_t > 1.0$	
	% WEIGHT SAVINGS	% MINIMUM LIFE EXTENSION*	% WEIGHT SAVINGS	%MINIMUM LIFE EXTENSION
Alum.-Graphite (AF-126 Adhesive)	37	68	37	100
Alum.-Glass	0	40 to 50	0	100
Alum.-Graphite (EA-927R Adhesive)	37	30	37	100

* For aluminum stress levels at or below limit stress.

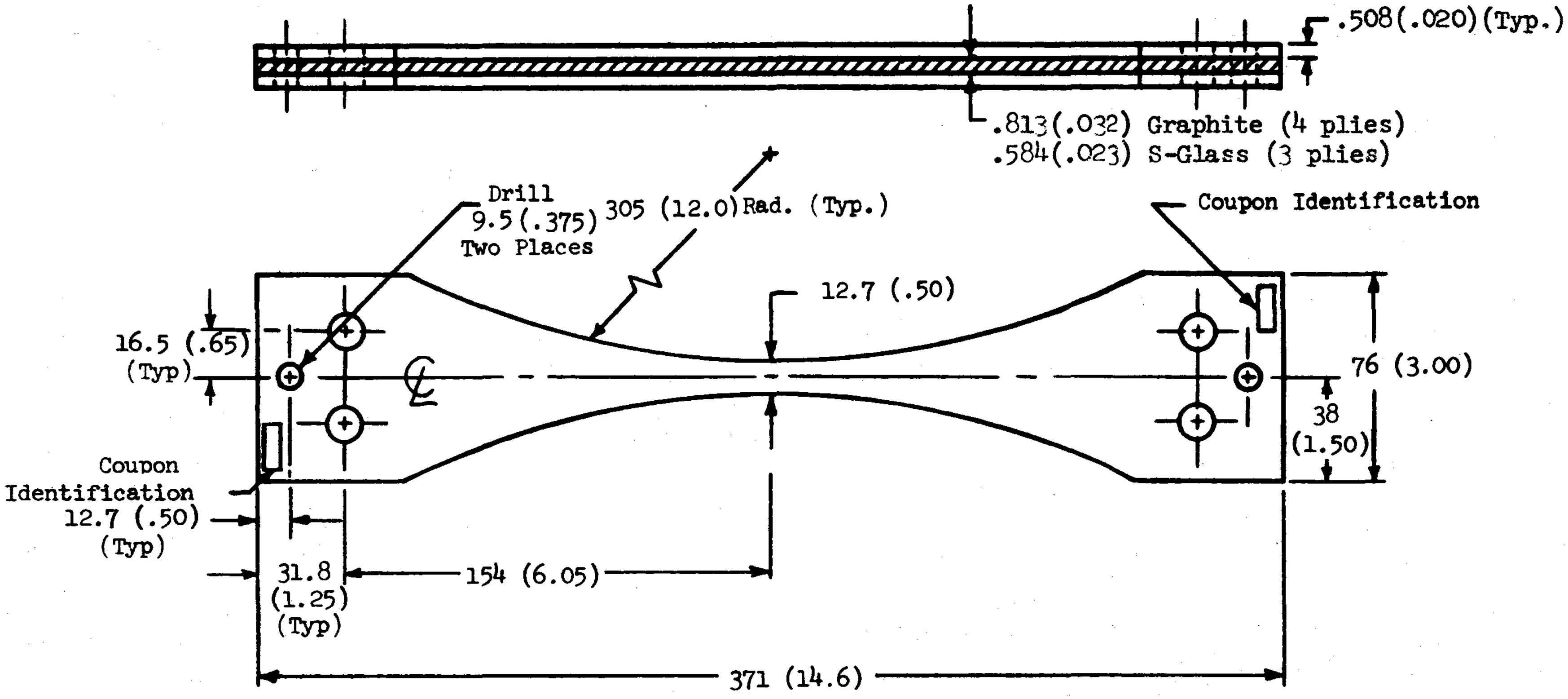


FIGURE 20 FATIGUE COUPON SPECIMEN

(Dimensions in Millimeters and Inches Respectively)

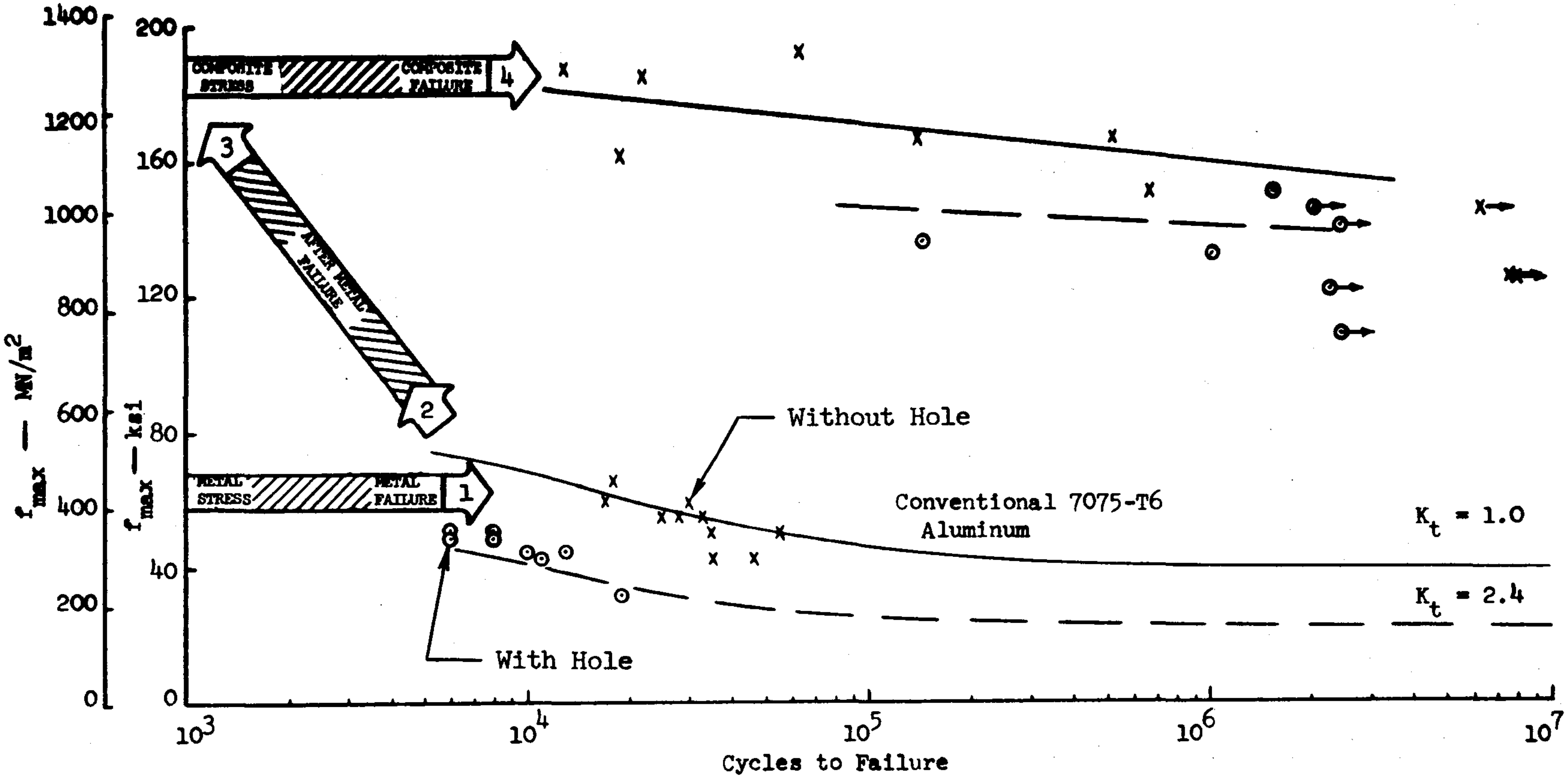


FIGURE 21 FATIGUE LIFE CURVE
ALUMINUM-GRAPHITE
AF-126 Adhesive
$\mu = 0.57$, $R = 0.10$

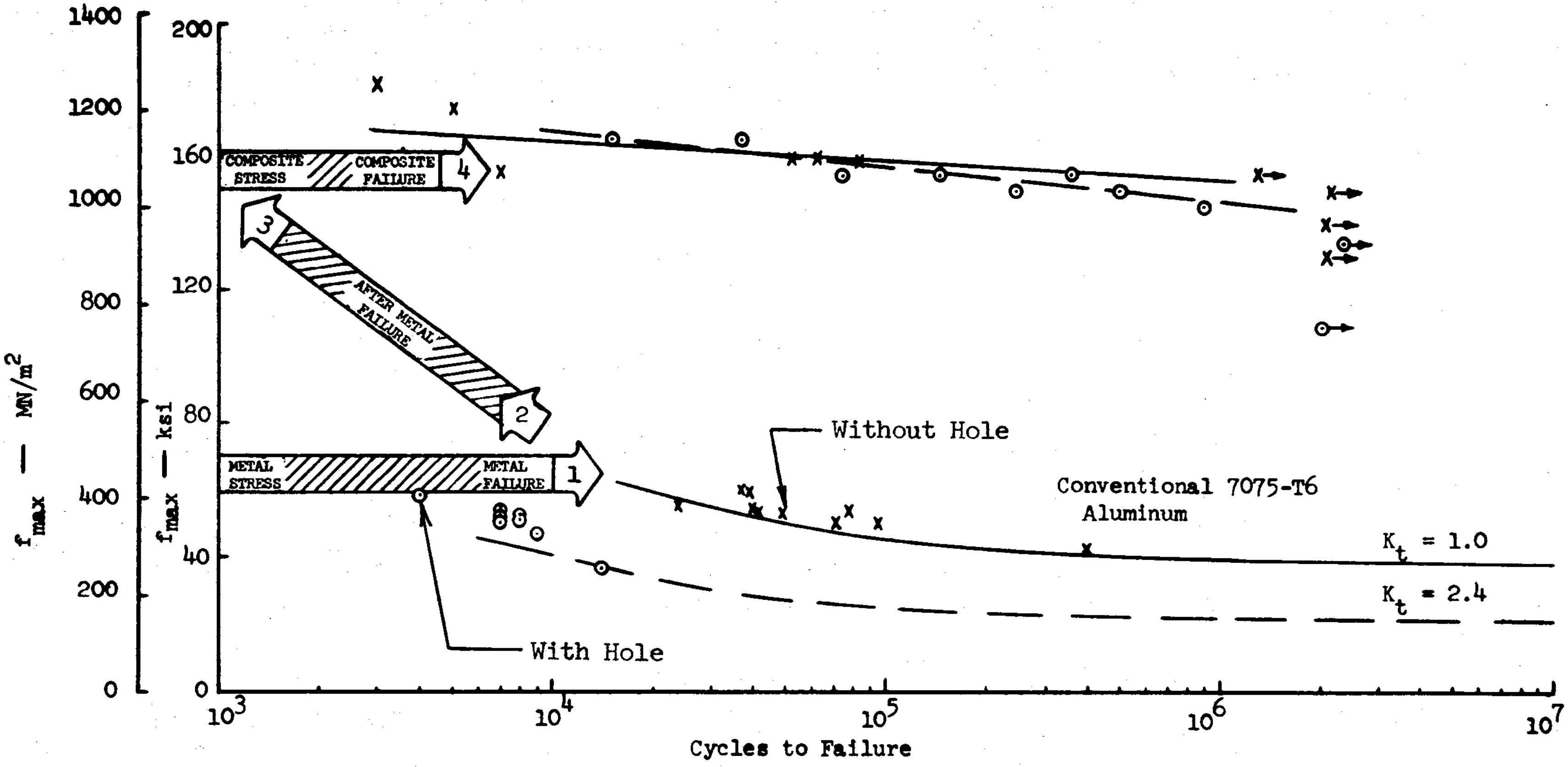


FIGURE 22 **FATIGUE LIFE CURVE**
ALUMINUM-GRAPHITE
EA-927R Adhesive
$\mu = 0.57$, R = 0.10

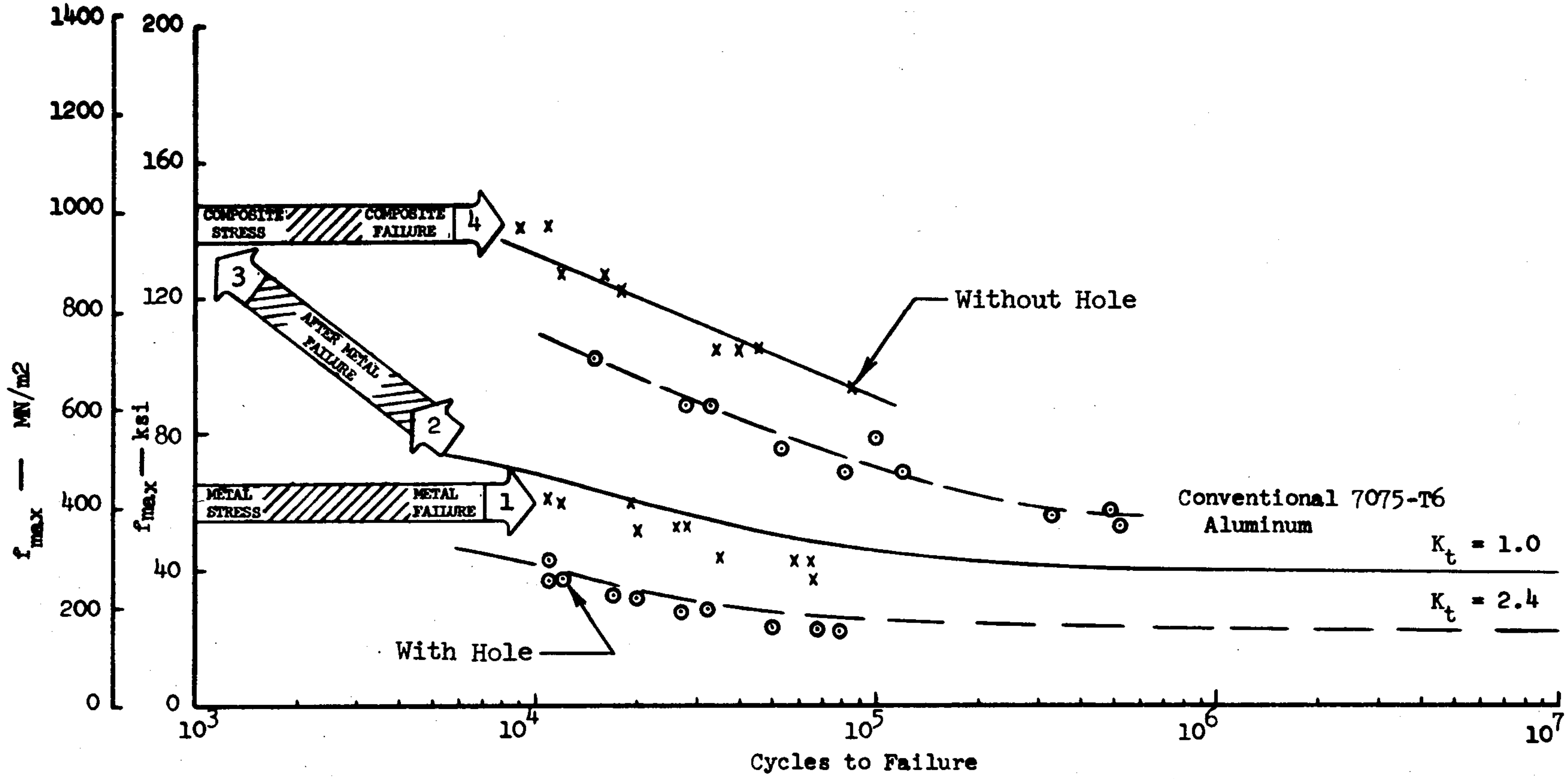


FIGURE 23 FATIGUE LIFE CURVE
ALUMINUM-GLASS
AF-126 Adhesive
$\mu = 0.29$, R = 0.10

PANEL STATIC LOAD DISTRIBUTION

Objective

The objective of this part of the program was to verify the load distribution in the all metal and the composite reinforced integrally formed panels.

Approach

Photostress analysis was conducted on one panel in each of the four groups of panels, all aluminum, aluminum-glass, aluminum-graphite (elevated temperature cure adhesive), and aluminum-graphite (room temperature cure adhesive). Photoelastic coatings were applied on each of the four panels as shown in Figures 24 through 27. The results of the photoelastic analysis were compared to strain gage readings.

Each panel was instrumented with strain gages to obtain panel strain distribution in the test region. Typical strain gage locations for a panel with and without photoelastic coating is shown in Figures 28 through 30.

Test Specimens

One all-metal, integrally-stiffened panel (1C) was fabricated from 7075-T6 aluminum. The inner and outer sheets were each 0.51 mm (0.020 in.) thick and bonded together with AF-126 adhesive.

Fourteen composite-reinforced, integrally-stiffened metal panels were fabricated. The configuration of these panels is shown in Figure 31 and the panel identification is given in Table VIII. The stiffness ratios for these panels are 0.57 for the aluminum-graphite materials and 0.29 for the aluminum-glass materials.

Each panel was 762 mm (30 in.) long, 305 mm (12 in.) wide. Each panel was necked down to 241 mm (9.5 in.) at the test section with the exception of panels 1C, 3C and 8C. A crack starter hole, 6.4 mm (0.250 in.) diameter, was drilled in the center of the panel. Individual fittings were bonded and bolted to each end of the panels to provide attachment to the testing machine.

Testing and Results

Photoelastic testing was conducted on the four panels described previously. Figure 24 through 27 show the specific points observed on the photostress coatings, O1 through O3 and I1 through I3. Observations were made and data recorded at several static load levels. The photostress data was compared to strain gage data at similar locations on the panel. Results of these comparisons are shown in Tables IX through XII.

Strain gage surveys were conducted on all panels. The panel strain distribution was brought to zero at a total load of 11,120 N (2500 lbf) and loaded in increments to the test load or a load in excess of the test load. Strain readings at the maximum load levels for panels 1C, 3C, 8C, and 12C are presented in Tables XIII through XVI. Strain gage readings were used to verify the correct aluminum stress level in each panel and insure equal load distribution across the panel test section.

Discussion

The photostress data of Table IX through Table XII provides a method of obtaining the stress concentration at the edge of the quarter inch diameter hole. A value for the stress concentration factor was determined by dividing the average stress at the hole $(f_{O3}+f_{I3})/2$, by the stress at some point on the panel that is not effected by stress risers (f_{I1}). The values of stress concentration factor calculated by this method are listed in Table XVII.

The aluminum stress at the panel test section for fatigue testing was determined both analytically and experimentally. Experimental determination was accomplished by obtaining the average test section strain, at or just above the fatigue test load, from strain gage readings and multiplying by the aluminum elastic modulus value (E) of 71,020 MN/m^2 (10,300 ksi).

The difference between panel test section maximum strain and minimum strain was held to 100 micromillimeters per millimeter (100 microinches per inch) in 89 kN (20,000 lbf) of total load.

Conclusions

The stress concentration values, calculated from the photostress data, indicate an increase in static stress concentration factors in the aluminum-composite panels when compared to the all aluminum panel. This increase in stress concentration factors is approximately twice the value of the all aluminum panel.

The panel strain gage data indicates relatively uniform stress distribution across the panel test section since the maximum stress is within 5 percent of the minimum stress.

TABLE VIII

PANEL IDENTIFICATION

Panel No.	Material Combination	Adhesive *	Measured Composite Thickness**		Test Section Width	
			mm	(in)	mm	(in)
1C	All Aluminum	AF-126	--	--	241.3	9.5
2C	Alum.-Graphite	AF-126	.787	0.031	241.3	9.5
3C	Alum.-Graphite	AF-126	.787	0.031	304.8	12.0
4C	Alum.-Graphite	AF-126	.813	0.032	241.3	9.5
5C	Alum.-Graphite	AF-126	.787	0.031	241.3	9.5
6C	Alum.-Graphite	AF-126	.813	0.032	241.3	9.5
7C	Alum.-Graphite	AF-126	.864	0.034	241.3	9.5
8C	Alum.-Galss	AF-126	.584	0.023	304.8	12.0
9C	Alum.-Glass	AF-126	.584	0.023	241.3	9.5
10C	Alum.-Glass	AF-126	.610	0.024	241.3	9.5
11C	Alum.-Glass	AF-126	.584	0.023	241.3	9.5
12C	Alum.-Graphite	EA-927R	.787	0.031	241.3	9.5
13C	Alum.-Graphite	EA-927R	.813	0.032	241.3	9.5
14C	Alum.-Graphite	EA-927R	.813	0.032	241.3	9.5
15C	Alum.-Graphite	EA-927R	.813	0.032	241.3	9.5

* AF-126 is cured at 389°K (250°F) and EA-927R is cured at room temperature

** All aluminum thicknesses were 0.51 mm (0.020 in.)

TABLE IX

PHOTOSTRESS COMPARISONS AT SPECIFIC POINTS FOR LOAD LEVEL OF 44.5 kN (10,000 lbf) (PANEL NO. 1C)

LOCATIONS	FRINGE ORDER	RELATED STRESS*		RELATED STRAIN**	STRAIN GAGE COMPARISONS + (IF APPLICABLE)			
					GAGE NO.	STRESS		STRAIN
	n	(MN/m^2)	(ksi)	(μ mm/mm)		(MN/m^2)	(ksi)	(μ mm/mm)
O1	1.38	56.7	8.23	1320				
O2	1.64	67.3	9.76	1570	AO-7***	63.4	9.20	1115
O3	2.60	106.5	15.45	2480				
I1	1.42	58.3	8.46	1360	AI-2	66.0	9.60	1165
I2	1.35	55.4	8.04	1290	AI-4	68.0	9.89	1200
I3	2.24	92.0	13.35	2140				

* Related Stress = F_σ Xn

where F_σ is the model stress fringe value for photostress plastic bonded to aluminum-aluminum composite structure (F_σ = 41.1 $MN/m^2 n$ (5.96 ksi/n))

** Related Strain = F_ϵ Xn

where F_ϵ is the model strain fringe value for photostress plastic bonded to aluminum-aluminum composite structure (F_ϵ = 955 μ mm/mm n (μ in/in n))

*** AO-7 is the closest symmetry gage to the particular photostress location.

+ E_T = 56,800 MN/m^2 (8,240 ksi) - Modulus of Total Structure

TABLE X

PHOTOSTRESS COMPARISONS AT SPECIFIC POINTS FOR
LOAD LEVEL OF 44.5 kN (10,000 lbf)
(PANEL NO. 3C)

LOCATIONS	FRINGE ORDER n	RELATED STRESS*		RELATED STRAIN**	STRAIN GAGE COMPARISONS + (IF APPLICABLE)			
		(MN/m^2)	(ksi)	(μ mm/mm)	GAGE NO.	STRESS (MN/m^2)	STRESS (ksi)	STRAIN (μ mm/mm)
O1	0.55	38.7	5.61	561				
O2	0.55	38.7	5.61	561	AO-7***	41.7	6.06	459
O3	2.00	140.7	20.40	2040				
I1	0.52	36.6	5.31	531	AI-2	42.9	6.23	472
I2	0.59	41.5	6.02	602	AI-4	45.8	6.64	504
I3	1.77	124.5	18.05	1800				

* Related Stress = F_σ Xn

where F_σ is the model stress fringe value for photostress plastic bonded to aluminum-graphite composite structure (F_σ = 70.3 MN/m^2n (10.2 ksi/n))

** Related Strain = F_ϵ Xn

where F_ϵ is the model strain fringe value for photostress plastic bonded to aluminum-graphite composite structure (F_ϵ = 1,020 μ mm/mm n (μ in/in n))

***AO-7 is the closest symmetry gage to the particular photostress location.

\+ E_T = 91,000 MN/m^2 (13,200 ksi) - Modulus of Total Structure (i.e. aluminum plus composite)

TABLE XI

PHOTOSTRESS COMPARISONS AT SPECIFIC POINTS FOR
LOAD LEVEL OF 44.5 kN (10,000 lbf)
(PANEL NO. 8C)

LOCATIONS	FRINGE ORDER	RELATED STRESS**		RELATED STRAIN**	STRAIN GAGE COMPARISONS + (IF APPLICABLE)			
					GAGE NO.	STRESS		STRAIN
	n	(MN/m^2)	(ksi)	(μ mm/mm)		(MN/m^2)	(ksi)	(μ mm/mm)
O1	0.85	31.6	4.58	765				
O2	0.72	26.8	3.88	648	AO-7***	43.1	6.25	796
O3	2.64	97.9	14.20	2380				
I1	0.83	30.8	4.47	747	AI-2	43.9	6.37	811
I2	0.81	30.1	4.36	729	AI-4	45.5	6.60	841
I3	2.55	94.5	13.70	2300				

* Related Stress = F_σ Xn

where F_σ is the model stress fringe value for photostress plastic bonded to aluminum-glass composite structure (F_σ = 37.1 $MN/m^2 n$ (5.38 ksi/n))

** Related Strain = F_ϵ Xn

where F_ϵ is the model strain fringe value for photostress plastic bonded to aluminum-glass composite structure (F_ϵ = 900 μ mm/mm n (μ in/in n))

***AO-7 is the closest symmetry gage to the particular photostress location.

\+ E_T = 54,100 MN/m^2 (7,850 ksi) - Modulus of Total Structure (i.e. aluminum plus composite)

TABLE XII

PHOTOSTRESS COMPARISONS AT SPECIFIC POINTS FOR
LOAD LEVEL OF 44.5 KN (10,000 lbf)
(PANEL NO. 12C)

LOCATIONS	FRINGE ORDER n	RELATED STRESS*		RELATED STRAIN**				
		(MN/m^2)	(ksi)	(μ mm/mm)	GAGE NO.	STRESS (MN/m^2)	STRESS (ksi)	STRAIN (μ mm/mm)
01	0.59	34.3	4.98	521				
02	0.51	29.7	4.31	451				
03	1.70	98.7	14.31	1,500				
I1	0.63	36.7	5.32	557	AI-2	44.1	6.40	508
I2	0.61	35.6	5.16	539	AI-4	44.4	6.44	511
I3	1.69	98.5	14.28	1,490				

* Related Stress = F_σ Xn

where F_σ is the model stress fringe value for photostress plastic bonded to aluminum-graphite composite structure (F_σ = 58.3 MN/m^2 n (8.45 ksi/n))

** Related Strain = F_ϵ Xn

where F_ϵ is the model strain fringe value for photostress plastic bonded to aluminum-graphite composite structure (F_ϵ = 883 μ mm/mm n (μ in/in n))

E_T = 87,000 MN/m^2 (12,600 ksi) - Modulus of Total Structure (i.e., aluminum plus composite)

TABLE XIII

STRAINS AT P_t = 89 kN (20,000 lbf)

(Panel No. 1C)

Gage No.	STRAIN $x10^{-6}$
AO-1	2330
AI-2	2330
AO-3	2375
AI-4	2400
AO-5	2230
AI-6	2242
AO-7	2230
AI-8	2230
AO-9	2200
AI-10	2235
AI-11	2210
AI-12	2250
AI-13	2242

TABLE XIV

STRAINS AT P_t = 156 kN (35,000 lbf)

(Panel No. 3C)

Gage No.	STRAIN $x10^{-6}$
AO-1	1568
AI-2	1653
AO-3	1706
AI-4	1764
AO-5	1603
AI-6	1653
AO-7	1605
AI-8	1584
AO-9	1603
AI-10	1722
AI-11	1654
AI-12	1673
AI-13	1688

TABLE XV

STRAINS AT P_t = 89 kN (20,000 lbf)

(Panel No. 8C)

Gage No.	Strain $x10^{-6}$
AO-1	1668
AI-2	1622
AO-3	1628
AI-4	1682
AO-5	1664
AI-6	1601
AO-7	1591
AI-8	1610
AO-9	1564
AI-10	1564
AI-11	1612
AI-12	1700
AI-13	1671

TABLE XVI

STRAINS AT P_t = 200 kN (45,000 lbf)

(Panel No. 12C)

Gage No.	Strain $x10^{-6}$
AO-1	2301
AI-2	2284
AO-3	2198
AI-4	2295
AO-5	2105
AI-6	2094
AO-7	3062
AI-8	2749
AO-9	1983
AI-10	1926
AI-11	1897
AI-12	2200
AI-13	2232

TABLE XVII

STRESS CONCENTRATION FACTORS DETERMINED FROM PHOTOSTRESS DATA

PANEL NUMBER	TYPE OF PANEL	AVERAGE STRESS AT HOLE $[(f_{O3} + f_{I3})/2]$		STRESS AWAY FROM HOLE (f_{I1})		STRESS CONCENTRATION FACTOR (K_t)
		MN/m^2	(ksi)	MN/m^2	(ksi)	
1C	All Aluminum	99.3	14.40	58.3	8.46	1.70
3C	Alum.-Graphite (Elev. Cure Adhesive)	132.5	19.22	36.6	5.31	3.62
8C	Alum.-Glass	96.2	13.95	30.8	4.47	3.12
12C	Alum.-Graphite (Room-Temp. Cure Adhesive)	98.6	14.30	36.7	5.32	2.69

FIGURE 24

LOCATIONS OF PHOTOSTRESS
COATINGS
PANEL NO. 1C

(Dimensions in millimeters and inches respectively)

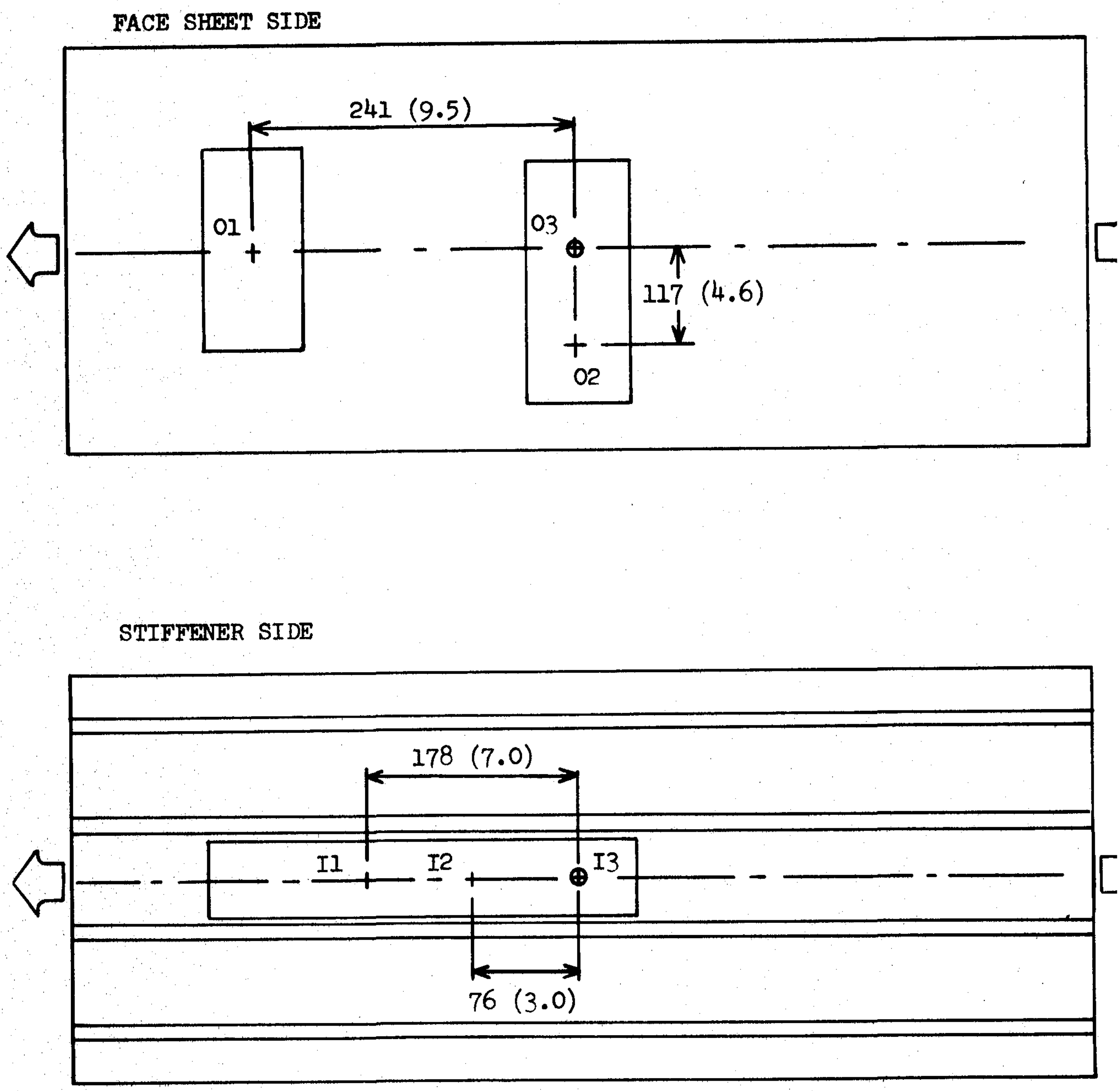
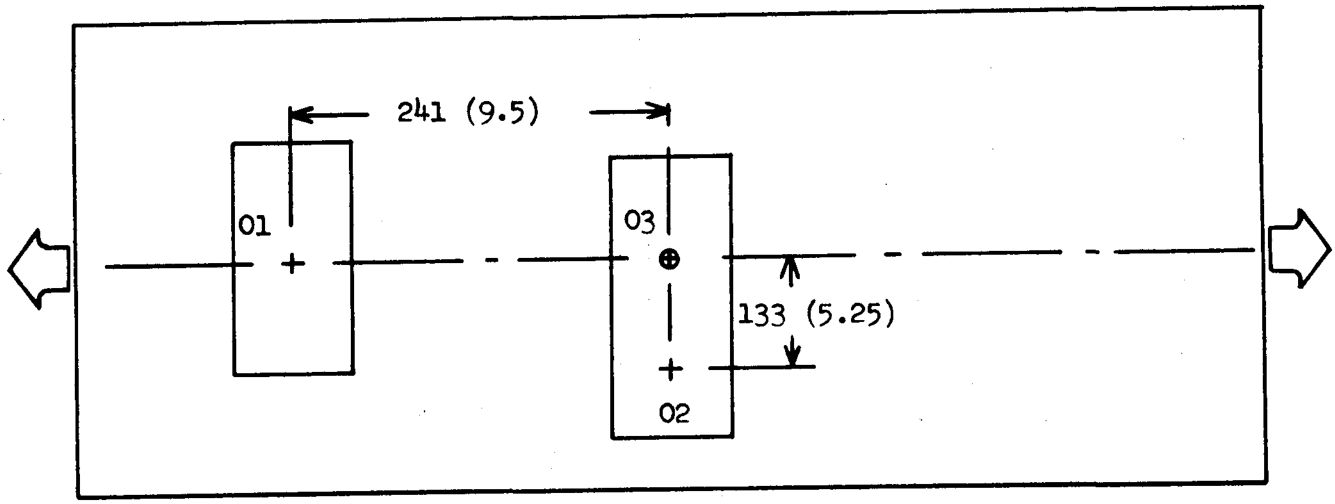


FIGURE 25

LOCATIONS OF PHOTOSTRESS
COATINGS
PANEL NO. 3C

(Dimensions in millimeters and inches respectively)

FACE SHEET SIDE



STIFFENER SIDE

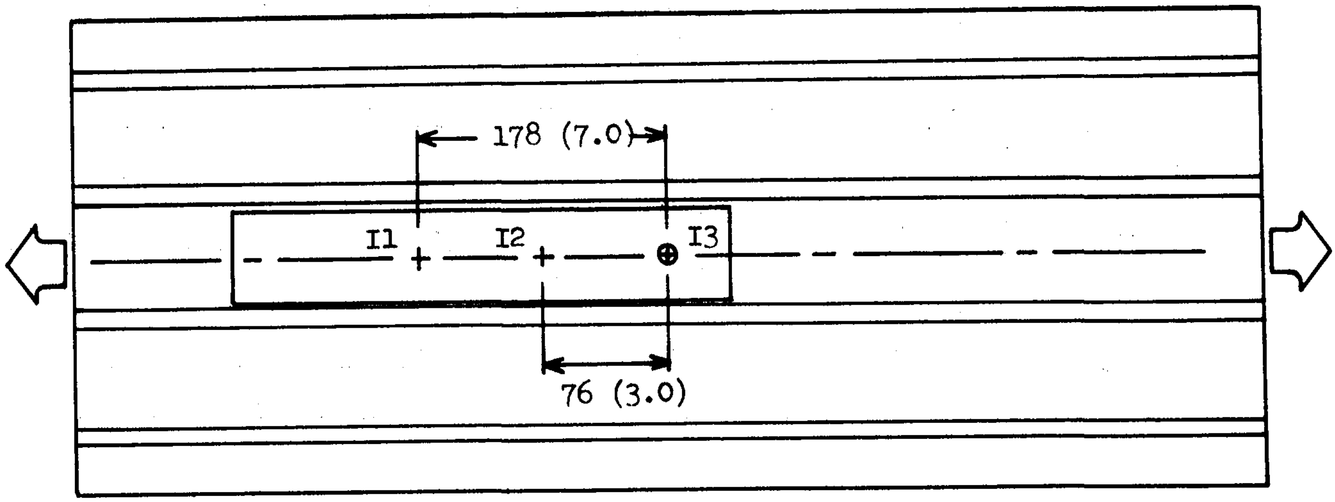
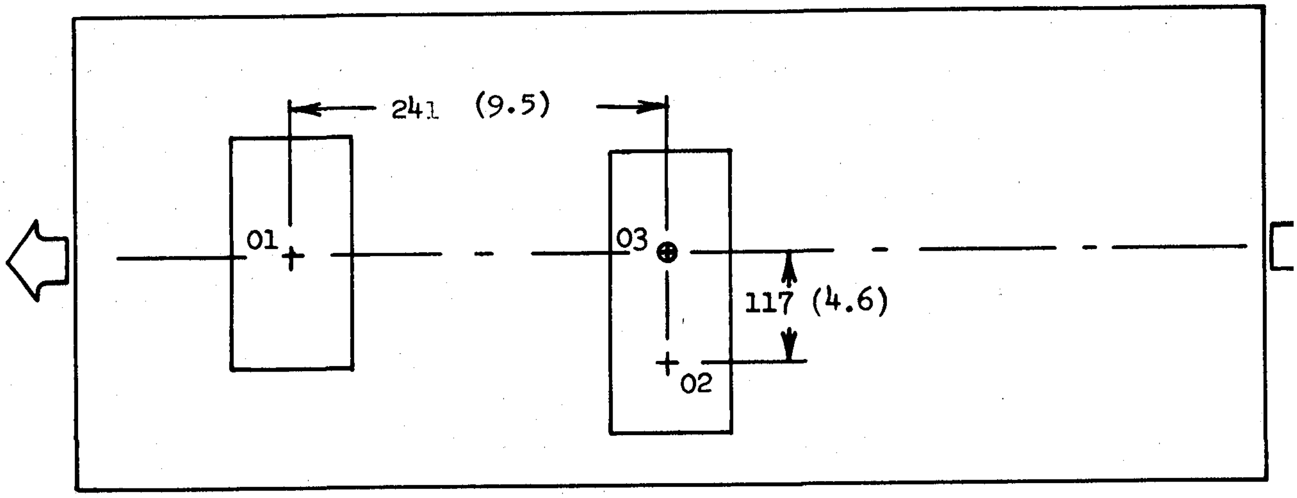


FIGURE 26
LOCATIONS OF PHOTOSTRESS
COATINGS
PANEL NO. 8C
(Dimensions in millimeters and inches, respectively)

FACE SHEET SIDE



STIFFENER SIDE

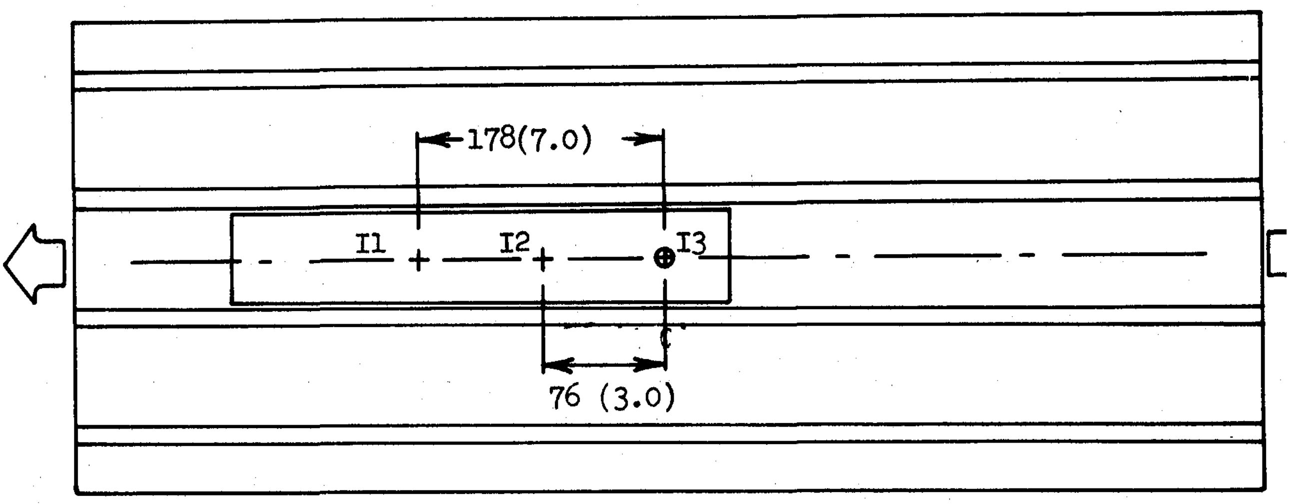
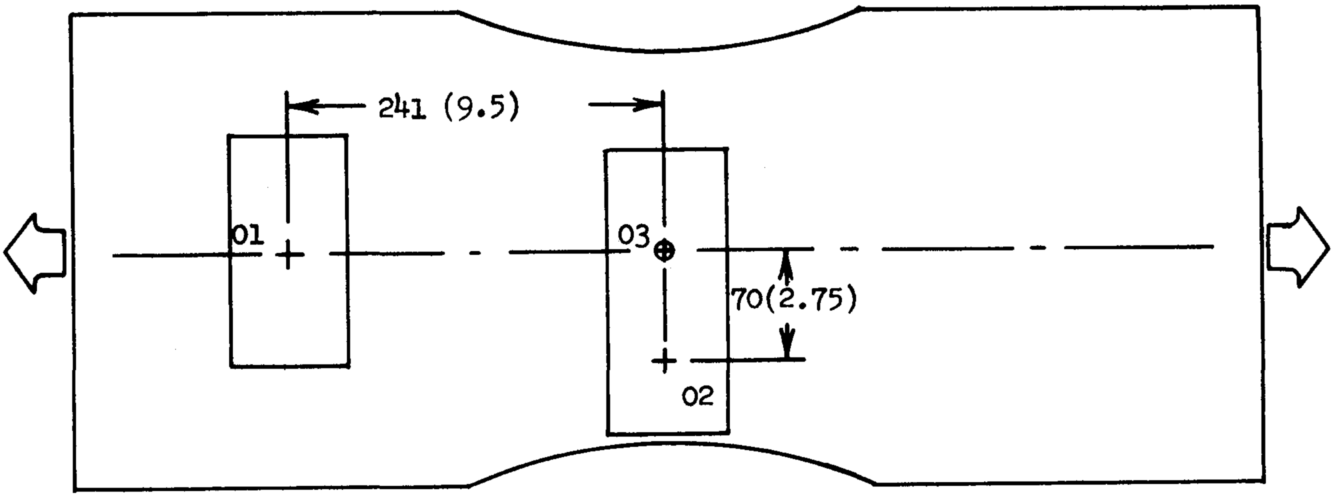
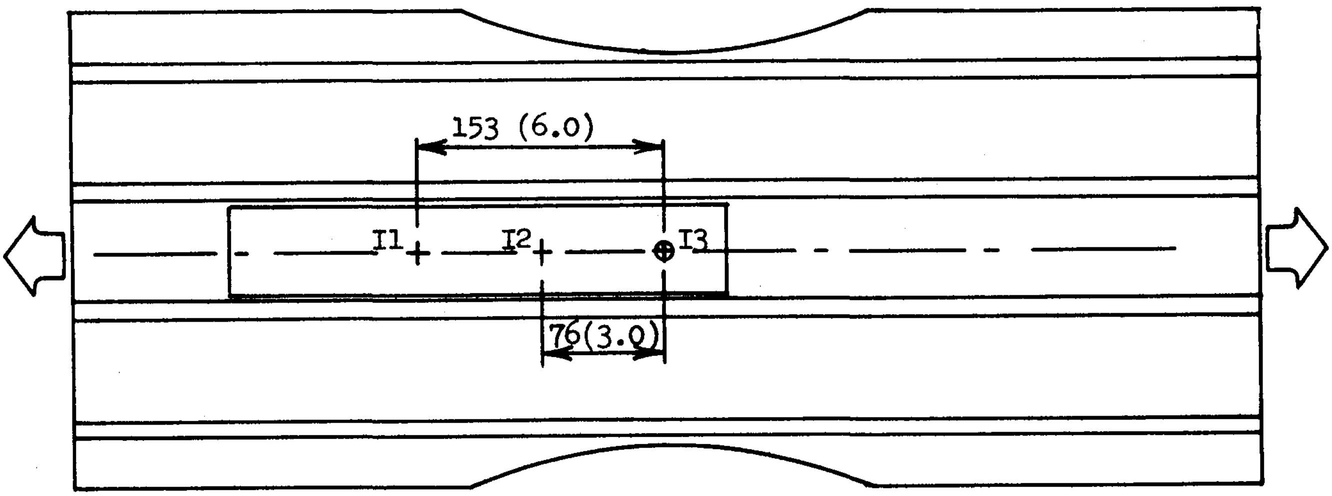


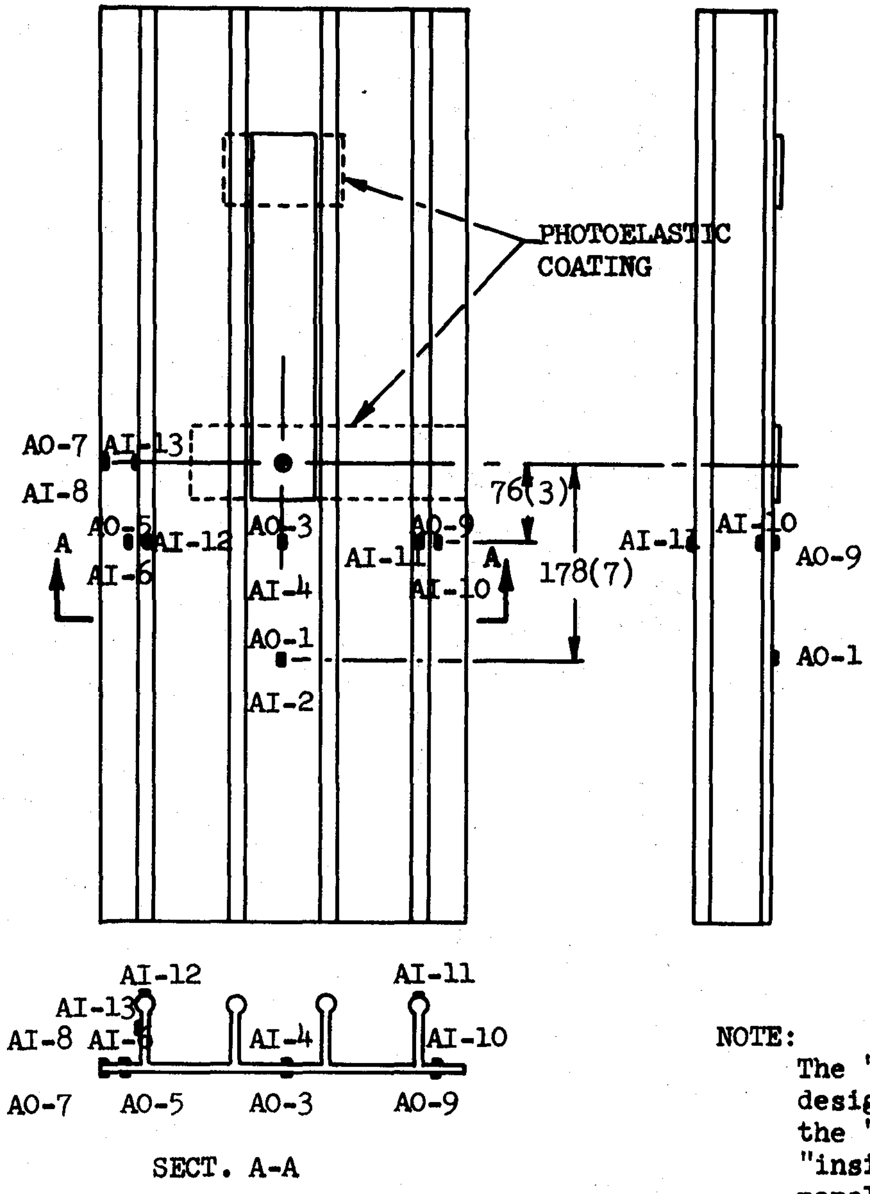
FIGURE 27
LOCATIONS OF PHOTOSTRESS
COATINGS
PANEL NO. 12C
(Dimensions in millimeters and inches, respectively)

FACE SHEET SIDE



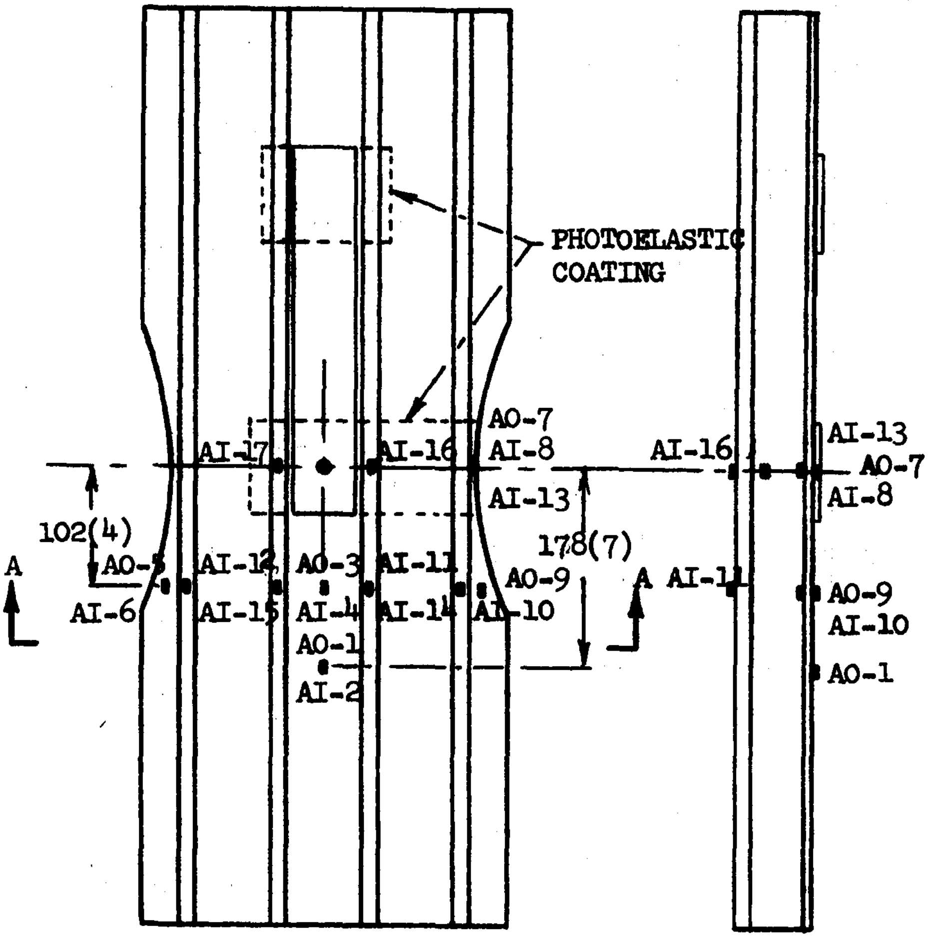
STIFFENER SIDE

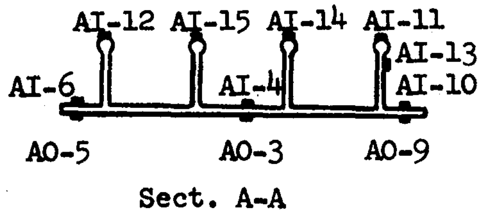




NOTE:
The "O" or "I" designation refers to the "outside" or "inside" face of the panel.

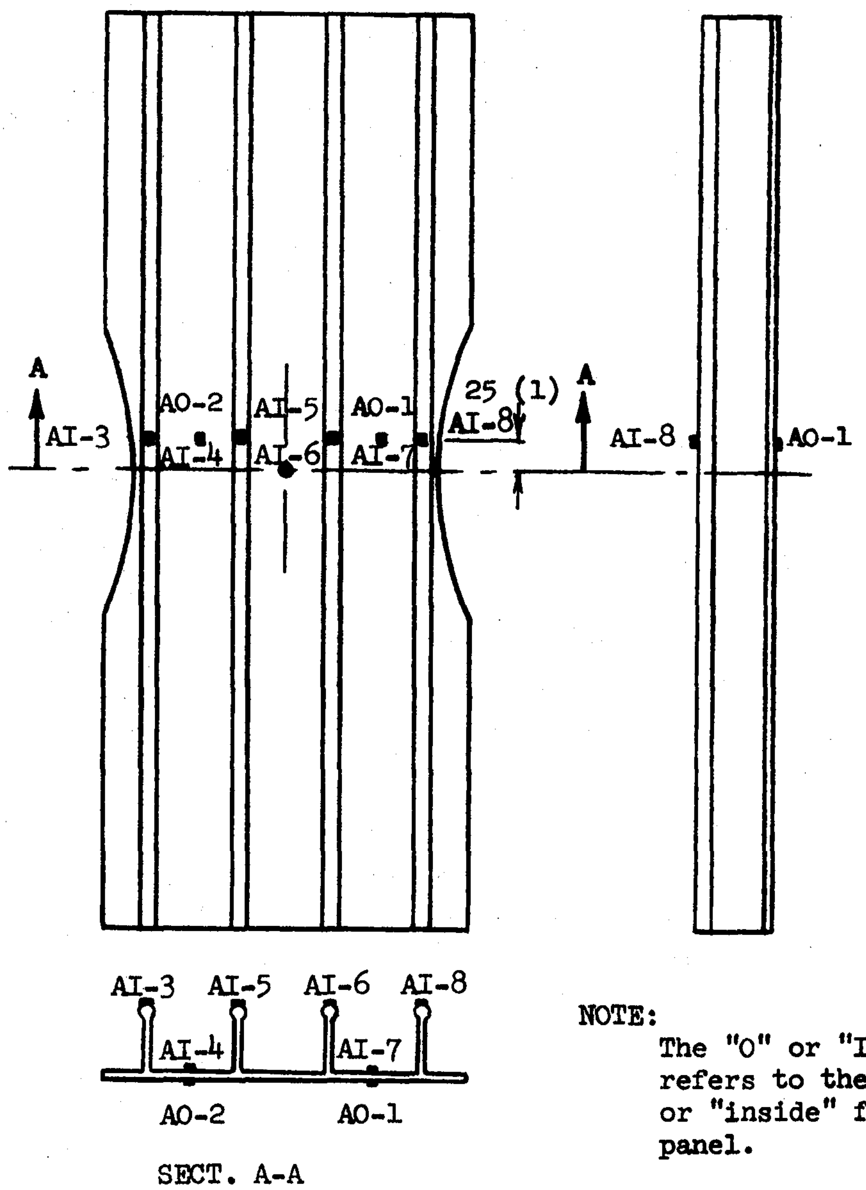
FIGURE 28 STRAIN GAGE AND PHOTOELASTIC COATING LOCATIONS
PANEL # 1C, #3C and #8C
(Dimensions in millimeters and inches respectively)





NOTE:
The "O" or "I" designation refers to the "outside" or "inside" face of the panel.

FIGURE 29 STRAIN GAGE AND PHOTOELASTIC COATING LOCATIONS PANEL #12C (Dimensions in millimeters and inches respectively)



NOTE:
The "O" or "I" designation refers to the "outside" or "inside" face of the panel.

FIGURE 30 STRAIN GAGE LOCATIONS, PANELS WITHOUT PHOTOELASTIC COATING (DIMENSIONS IN MILLIMETERS AND INCHES RESPECTIVELY)

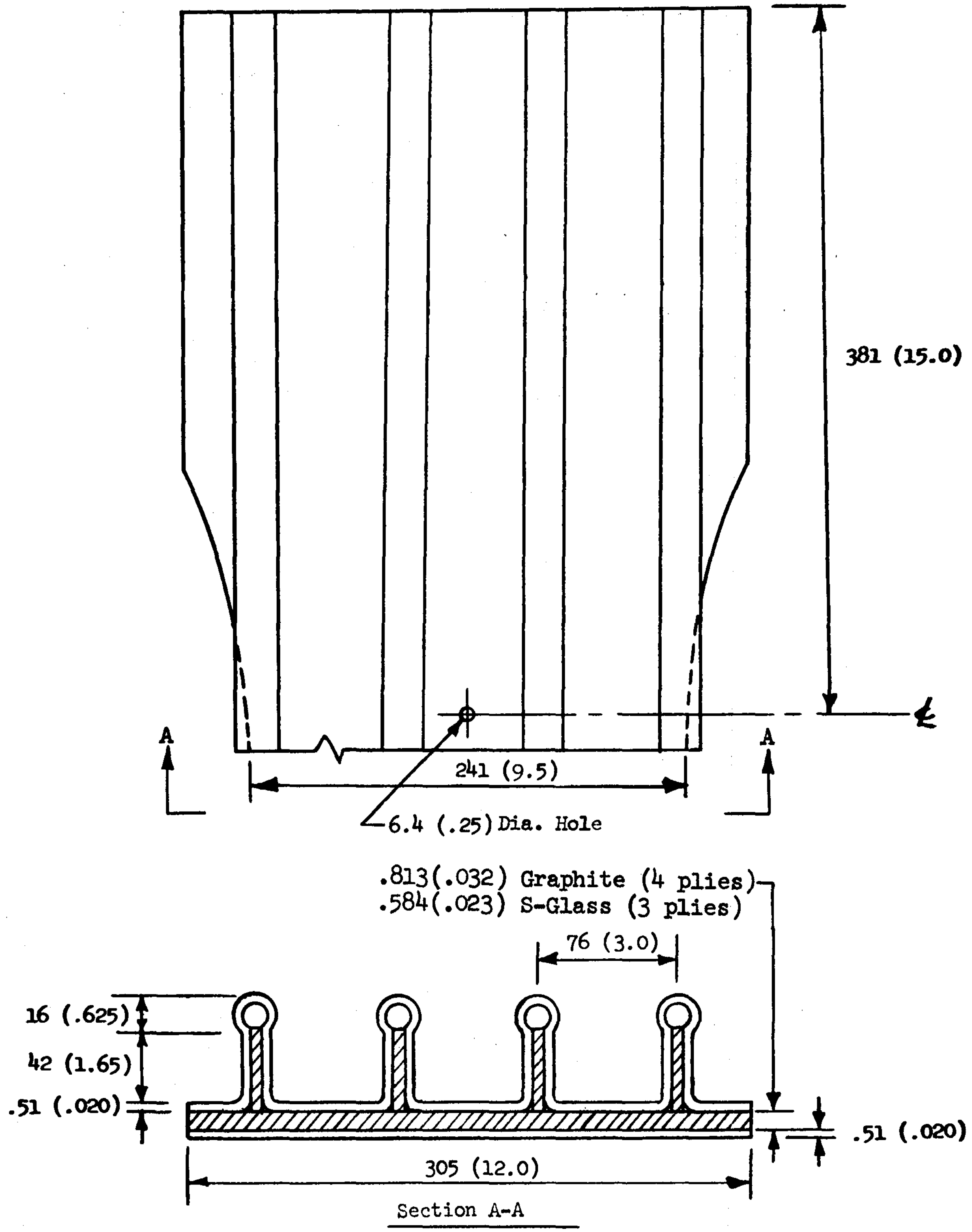


Figure 31 Composite-Reinforced, Integrally Stiffened Metal Panel (Dimensions in Millimeters and Inches, Respectively)

PANEL FATIGUE CRACK GROWTH

Objective

The objective of this portion of the program was to fatigue cycle the composite-reinforced, integrally stiffened metal panels and monitor and record the metal crack growth.

Approach

Composite-reinforced, integrally stiffened metal panels were fabricated and tested in fatigue to examine the metal crack growth characteristics. The metal crack growth for the different composite-metal systems was compared to each other for different levels of metal stress and also compared to the crack growth in an all metal integrally stiffened panel.

Testing and Results

The composite-reinforced, integrally-stiffened metal panels were cycled in tension-tension fatigue at constant amplitude and load ratio R = 0.10. The panels were tested at several levels of aluminum gross stress and the crack length (2a) and number of cycles were recorded. The gross stress in the metal stiffener and face sheets and composite materials was calculated in terms of the total applied load using Equations (2) and (3).

The panels were tested in a load fixture with hydraulic jacks with a load range of 0 to 445 kN (100,000 lbf). The loading frequency ranged from 1-10 Hz (60-600 cmp). The number of cycles required to initiate a crack in the metal at the test section hole was recorded. A paper grid scale with 1.27 mm (0.05 in.) increments was attached to the panel in line with the primary cracks in the panel test section. A 30-powered transit with crossed hair lines and mounted on adjustable stands was used to read crack length increments every 1.27 mm (0.05 in.). There were primarily four cracks to monitor, a crack to each side of the panel centerline on both the stiffener and face sheet sides.

Figure 32 shows the results of the crack growth of the panel face sheet at three different stress levels for three composite-metal-adhesive combinations. The panel crack length (2a) and the number of cycles are plotted starting at a crack length (2a) of 25.4 mm (1.0 in.). Each band shown contains the three different panels examined, aluminum-graphite bonded with AF-126 adhesive, aluminum-graphite bonded with EA-927R adhesive and aluminum-glass bonded with AF-126 adhesive.

Figures 33 through 47 show the results of the fifteen tested panels. These figures show plots of the primary crack length (2a) on both the face and stiffener sheets versus number of cycles. The recorded test data is given in Appendix F.

Discussion

It can be seen from Figure 32 that, as the gross stress increases, the crack growth in the aluminum also increases, but the crack growth in the composite-metal panels with a stress 2/3's greater than the all-aluminum panel stress is still much less than the all-aluminum panel crack growth. The aluminum-graphite panels with the two different adhesive systems show to have no significant differences in crack growth characteristics. The aluminum-glass panels have a much faster crack growth rate than the aluminum-graphite panels for the same stress levels, e.g., approximately 100% faster at 103 MN/m^2 (15 ksi), 15% at 138 MN/m^2 (20 ksi), and 65% at 172 MN/m^2 (25 ksi).

Conclusions

The crack growth panel tests show that the metal crack growth rates for the composite-metal systems investigated are essentially constant. The metal crack growth rates in the composite-metal systems are much slower than the all metal crack growth rates. This is true for the same gross metal stress and also for a gross metal stress which is 2/3's higher than the all metal stress (see Figure 32).

For the same gross metal stress, the crack growth rate of the aluminum-glass system is much higher than the aluminum-graphite system. Also, there is generally no significant crack growth rate differences for the two adhesives used in the aluminum-graphite system.

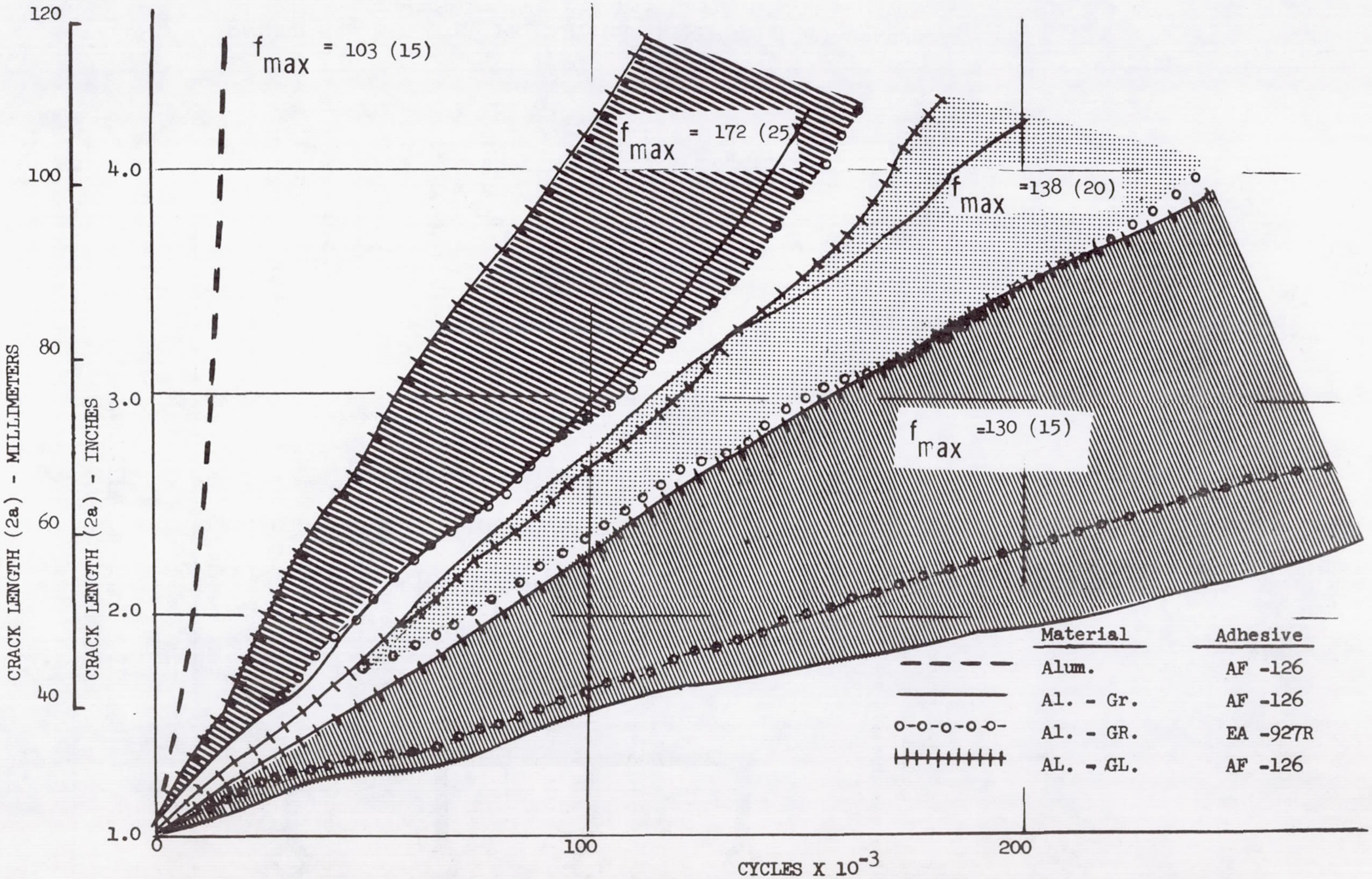


FIGURE 32 MEASURED CRACK LENGTH (2a) VERSUS NUMBER OF CYCLES FOR FACE SHEET OF COMPOSITE - REINFORCED, INTEGRALLY STIFFENED METAL PANELS (MAXIMUM STRESS, f_{max}, IS IN MN/m^2 AND KSI RESPECTIVELY)

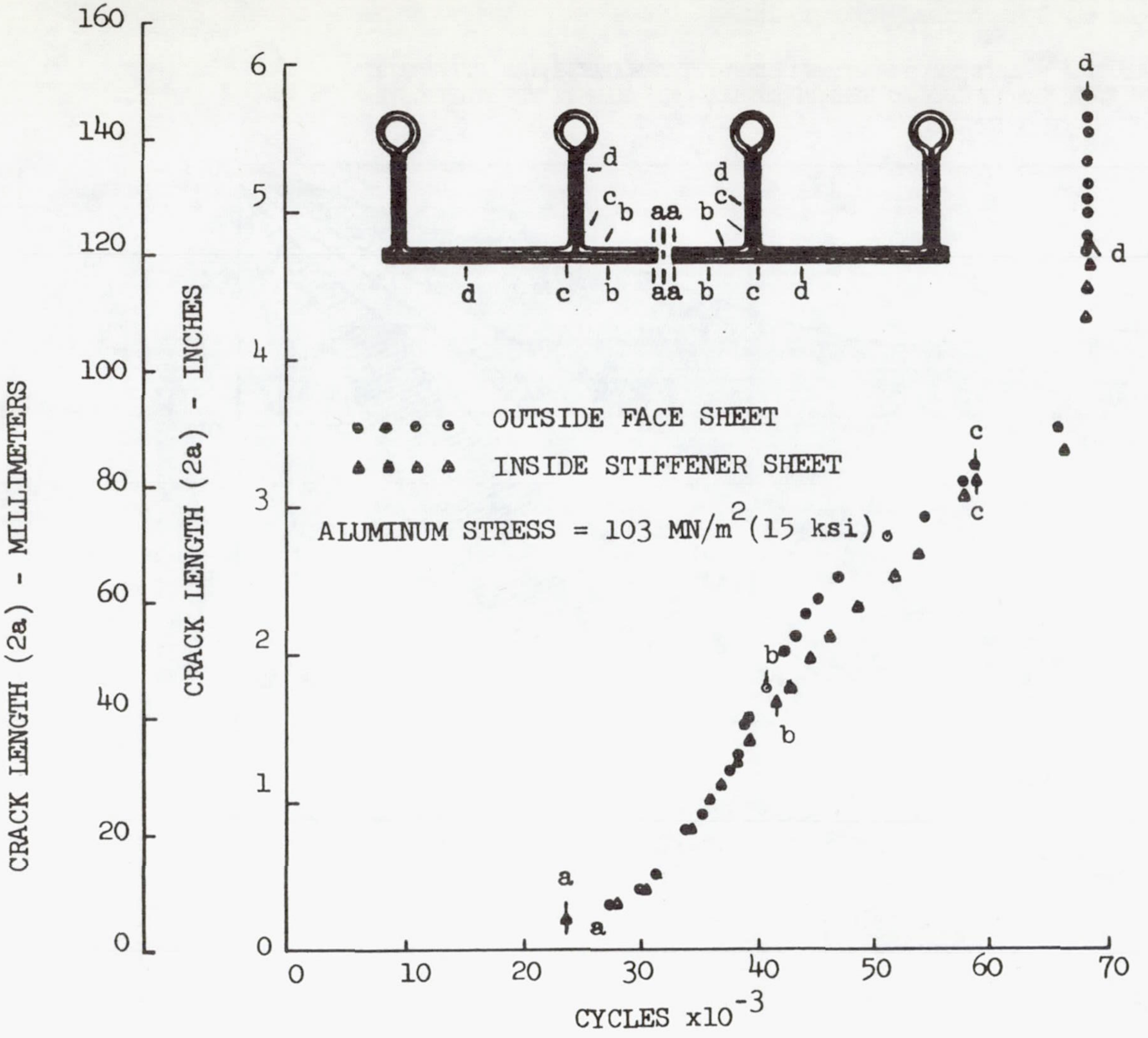


FIGURE 33 MEASURED PRIMARY CRACK LENGTH (2a) VERSUS NUMBER OF CYCLES, PANEL #1C

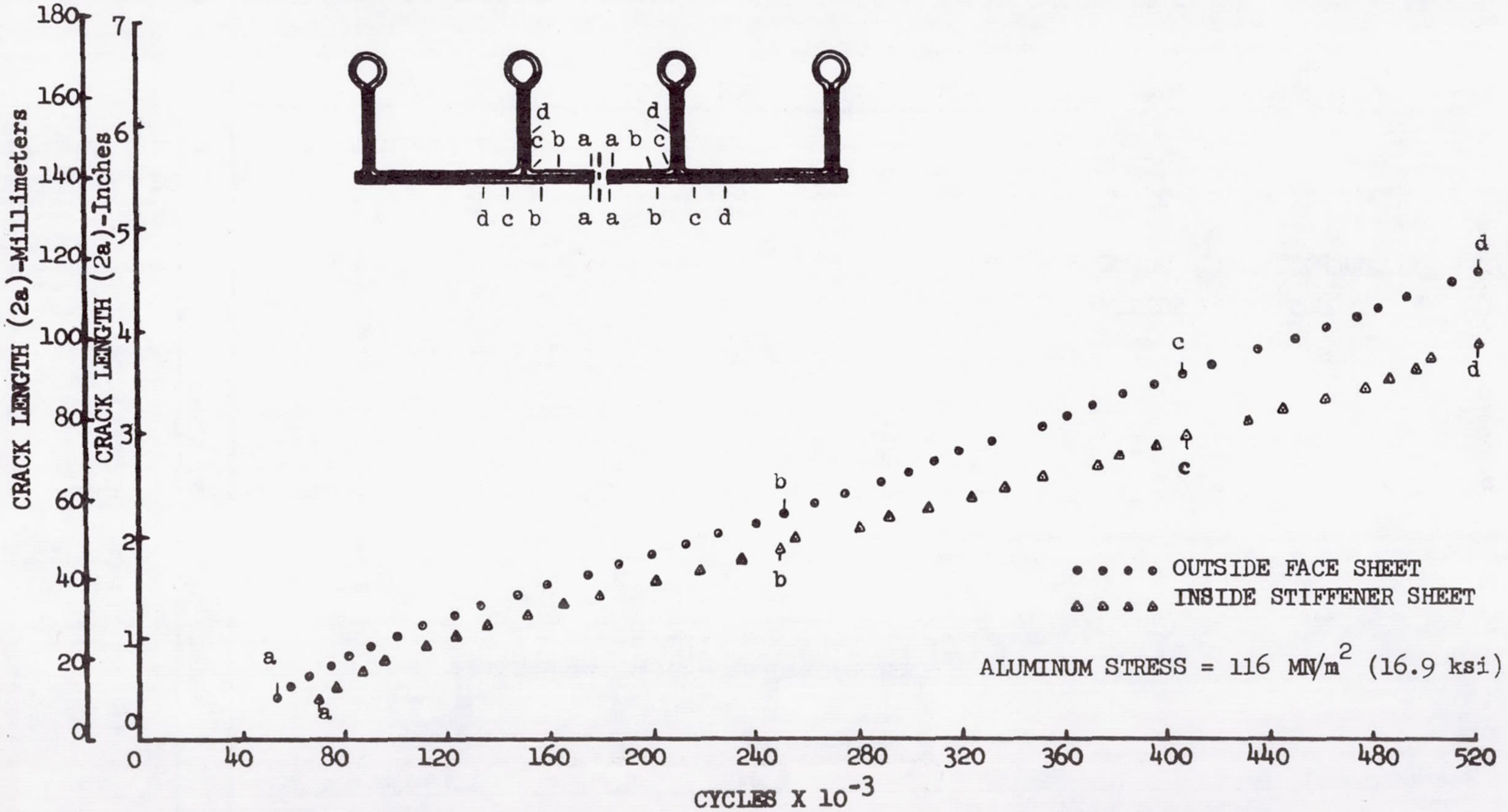


FIGURE 34 MEASURED PRIMARY CRACK LENGTH (2a) VERSUS NUMBER OF CYCLES, PANEL #2C

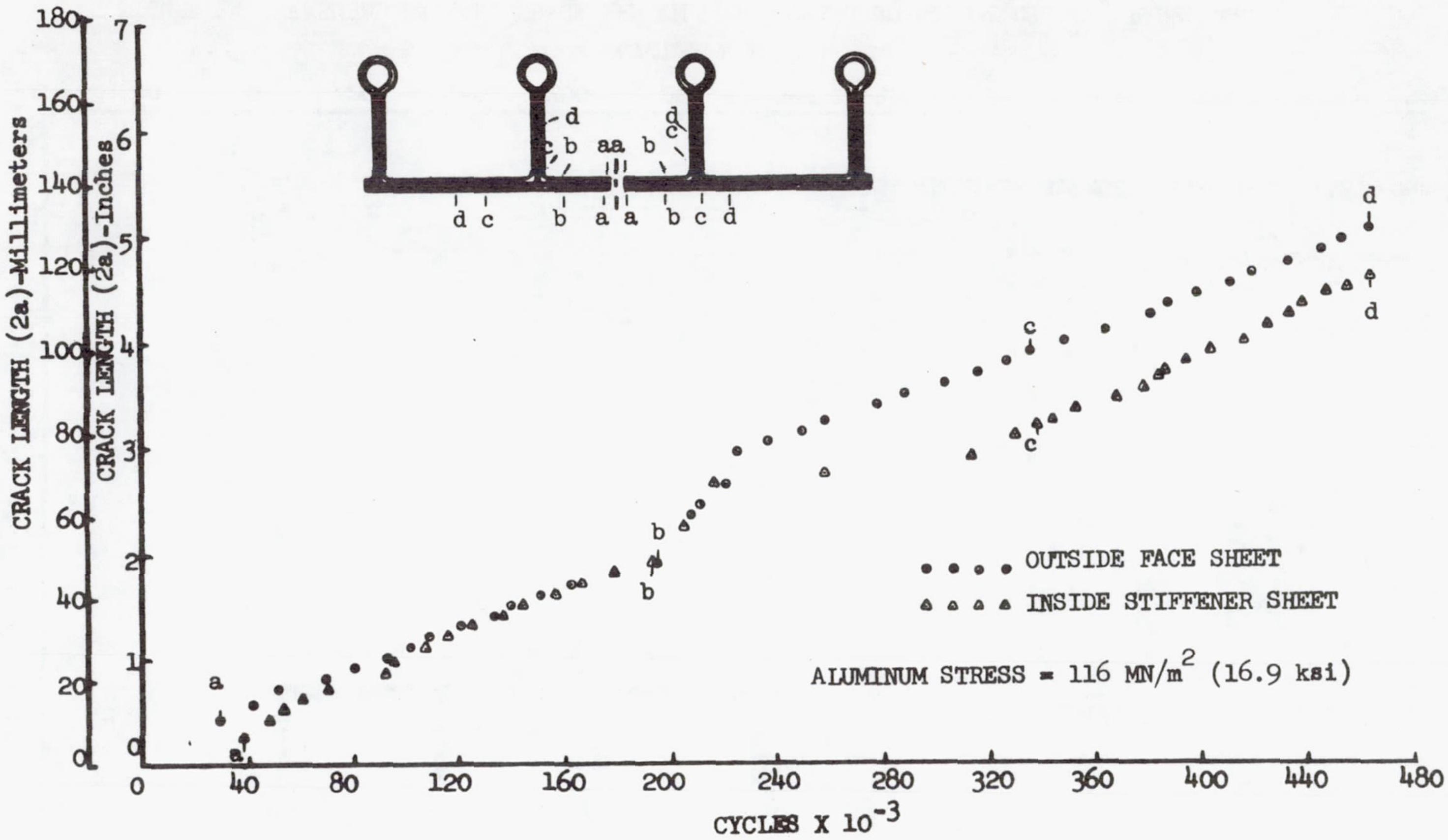


FIGURE 35 MEASURED PRIMARY CRACK LENGTH (2a) VERSUS NUMBER OF CYCLES, PANEL #3C

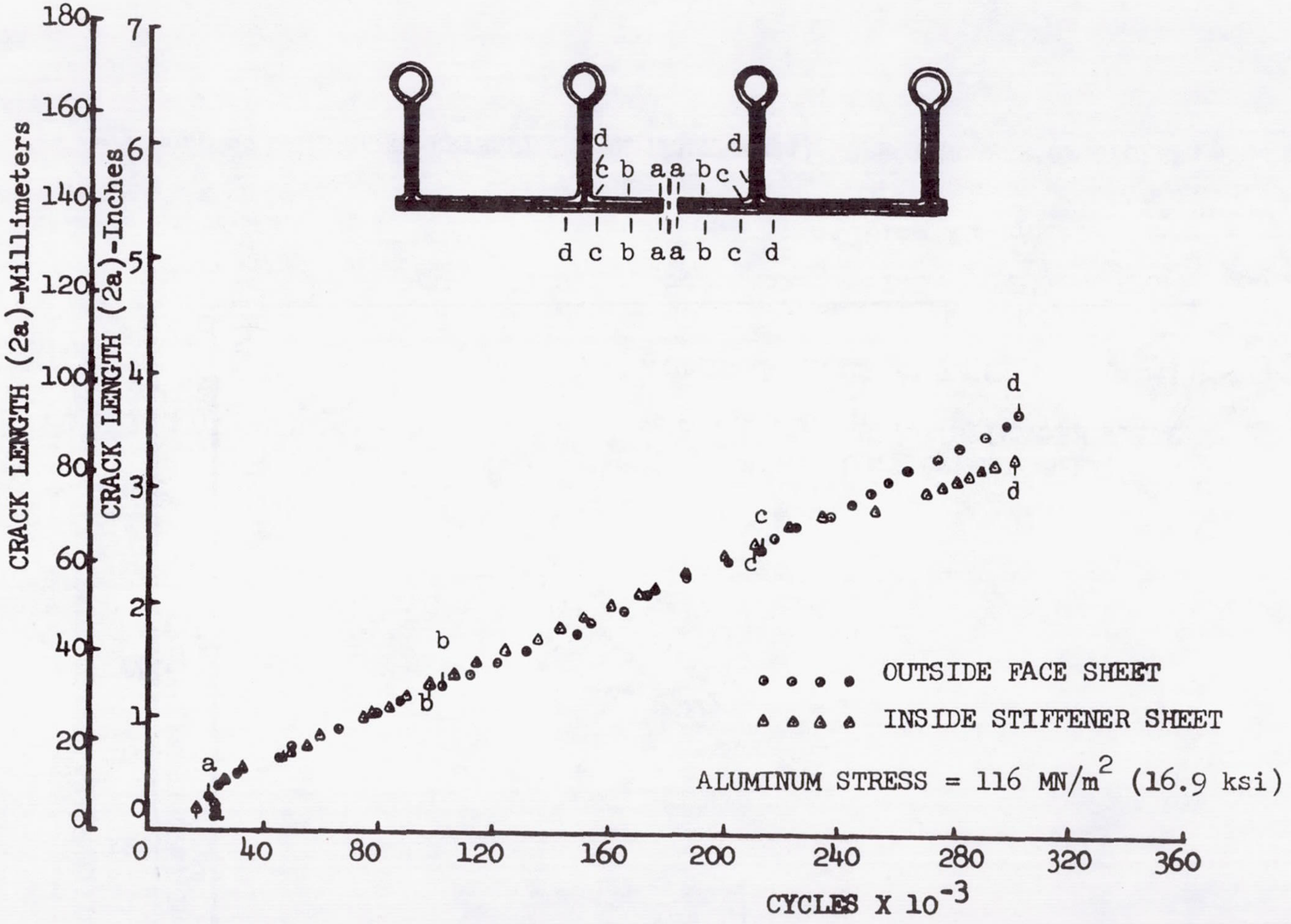


FIGURE 36 MEASURED PRIMARY CRACK LENGTH (2a) VERSUS NUMBER OF CYCLES, PANEL #4C

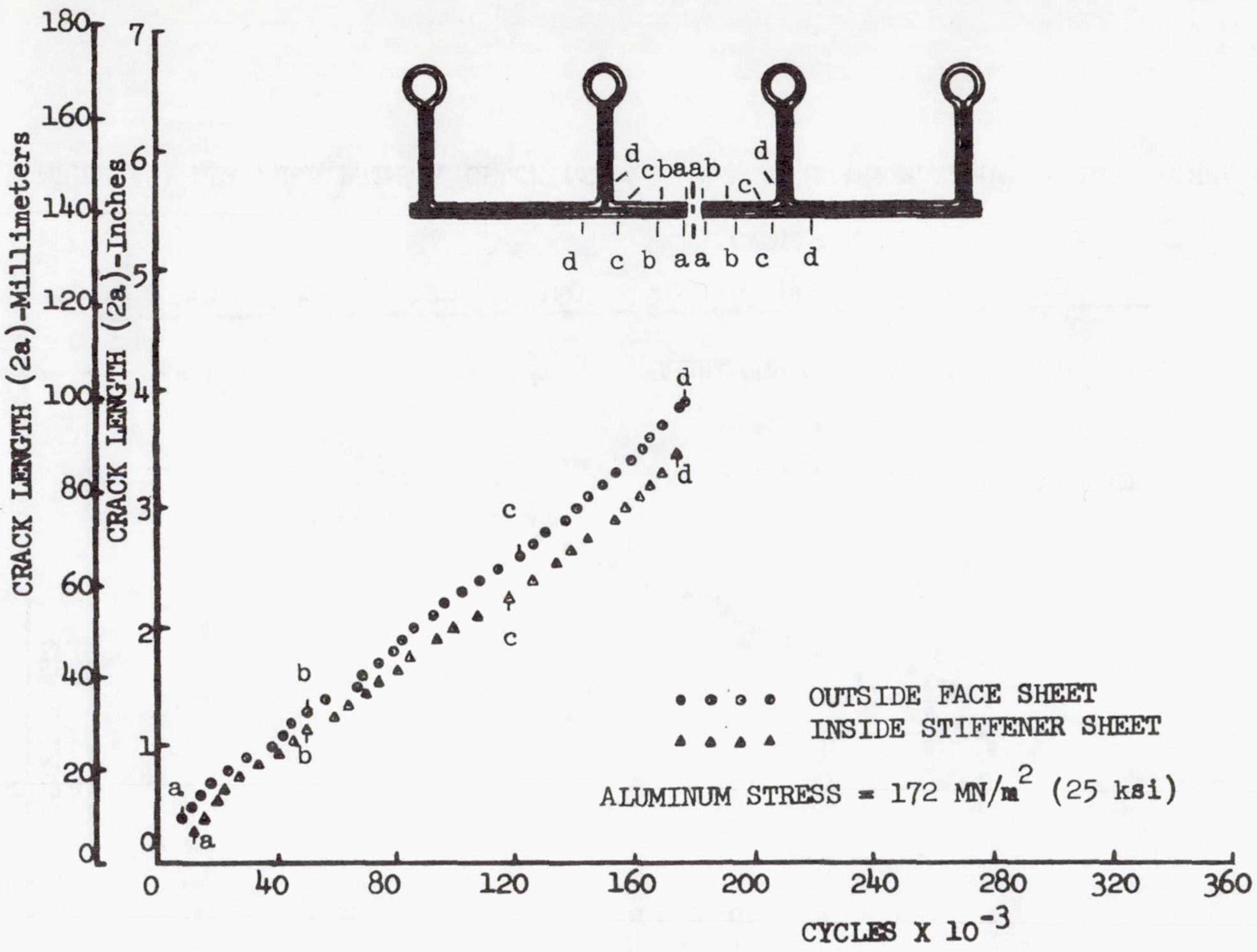


FIGURE 37 MEASURED PRIMARY CRACK LENGTH (2a) VERSUS NUMBER OF CYCLES, PANEL #5C

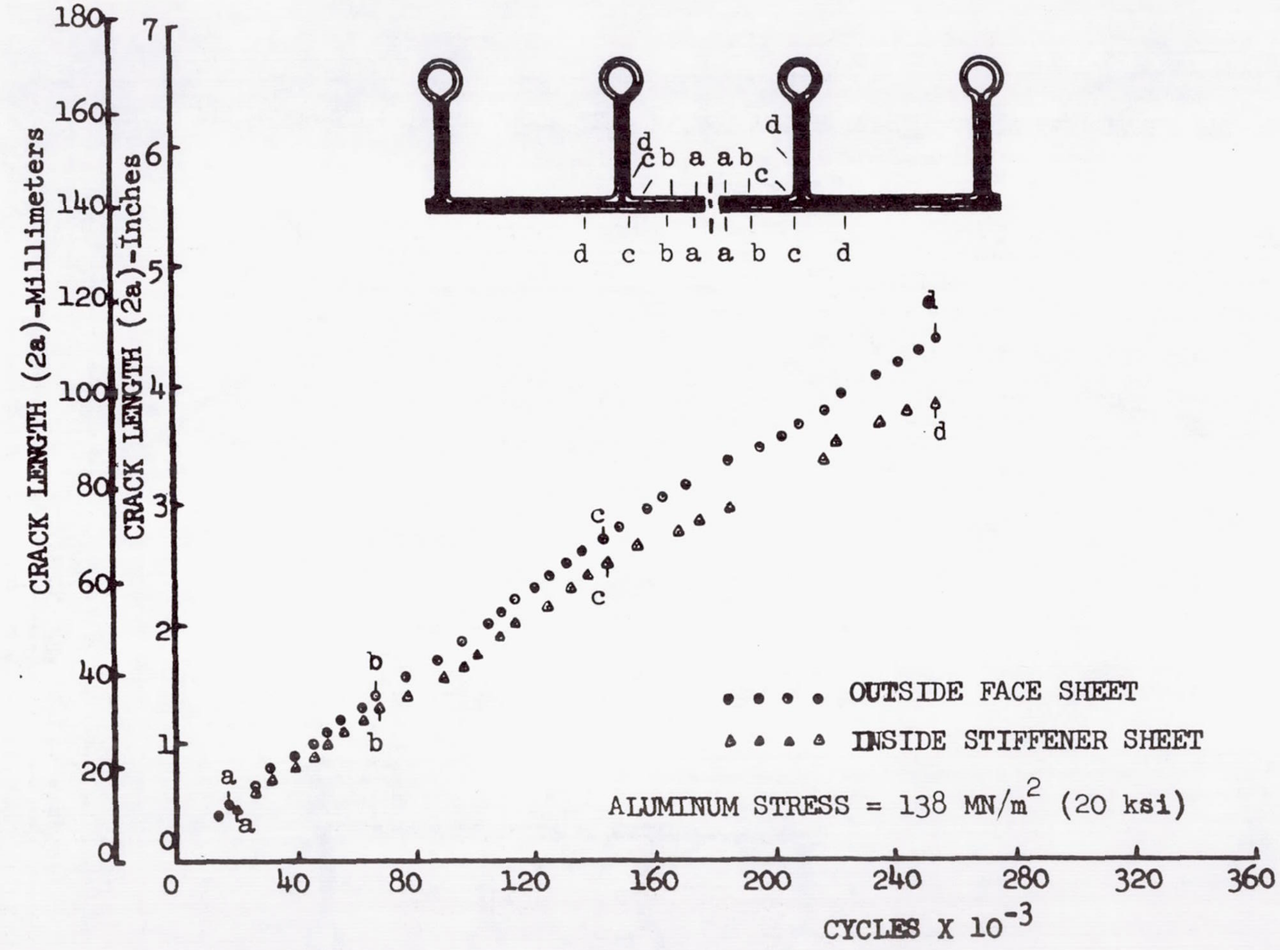


FIGURE 38 MEASURED PRIMARY CRACK LENGTH (2a) VERSUS NUMBER OF CYCLES, PANEL #6C

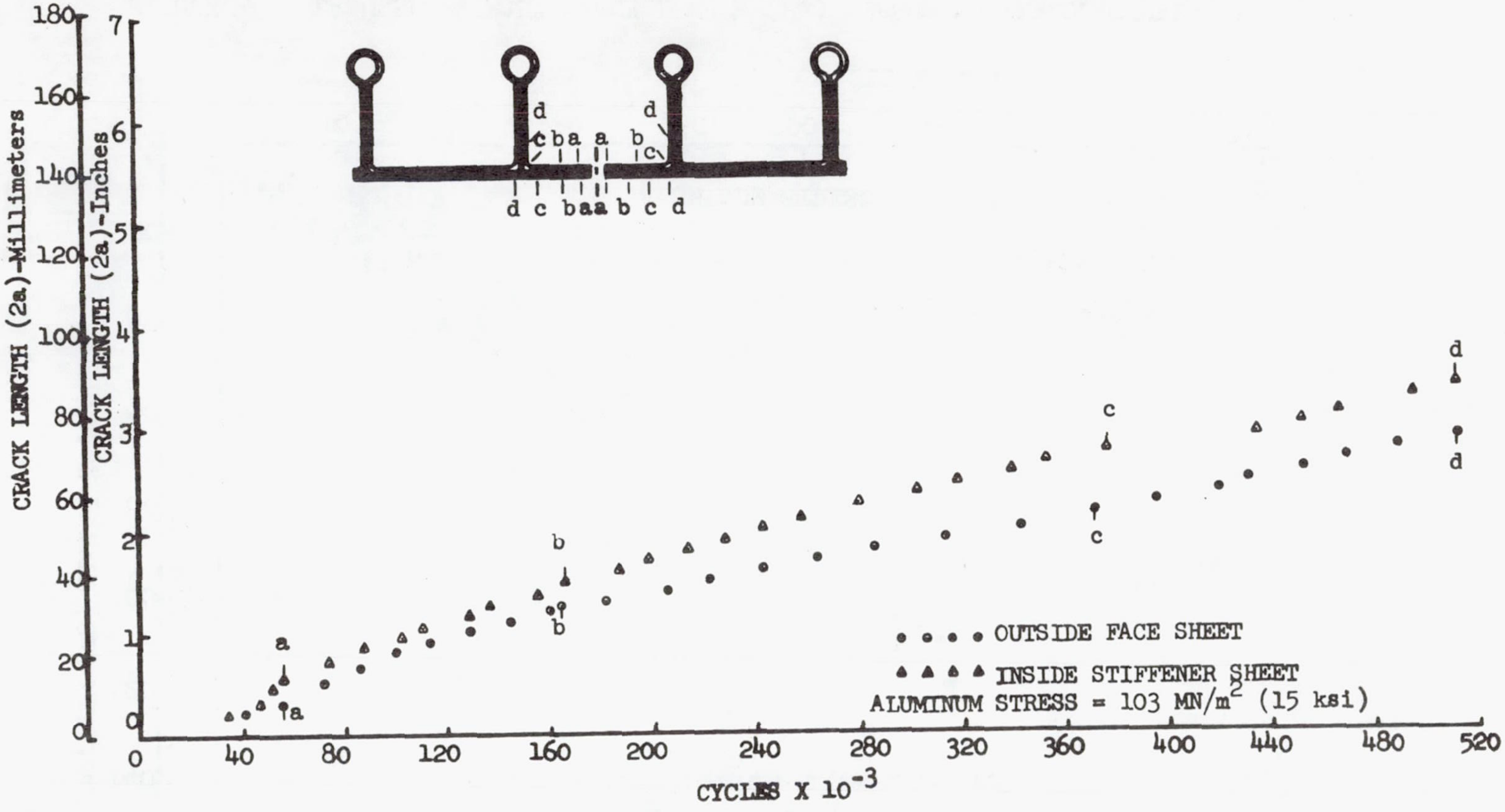


FIGURE 39 MEASURED PRIMARY CRACK LENGTH (2a) VERSUS NUMBER OF CYCLES, PANEL #7C

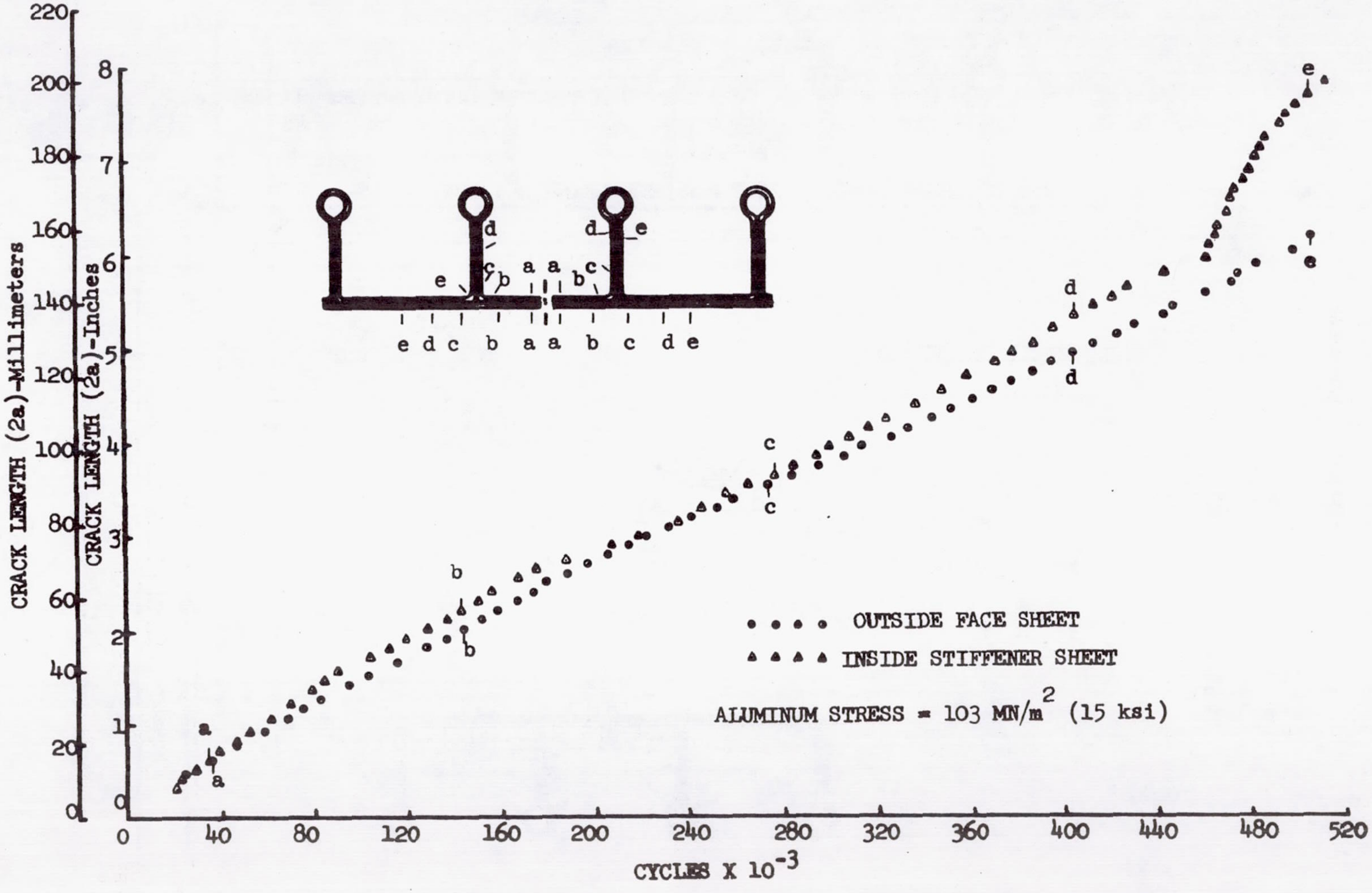


FIGURE 40 MEASURED PRIMARY CRACK LENGTH (2a) VERSUS NUMBER OF CYCLES, PANEL #8C

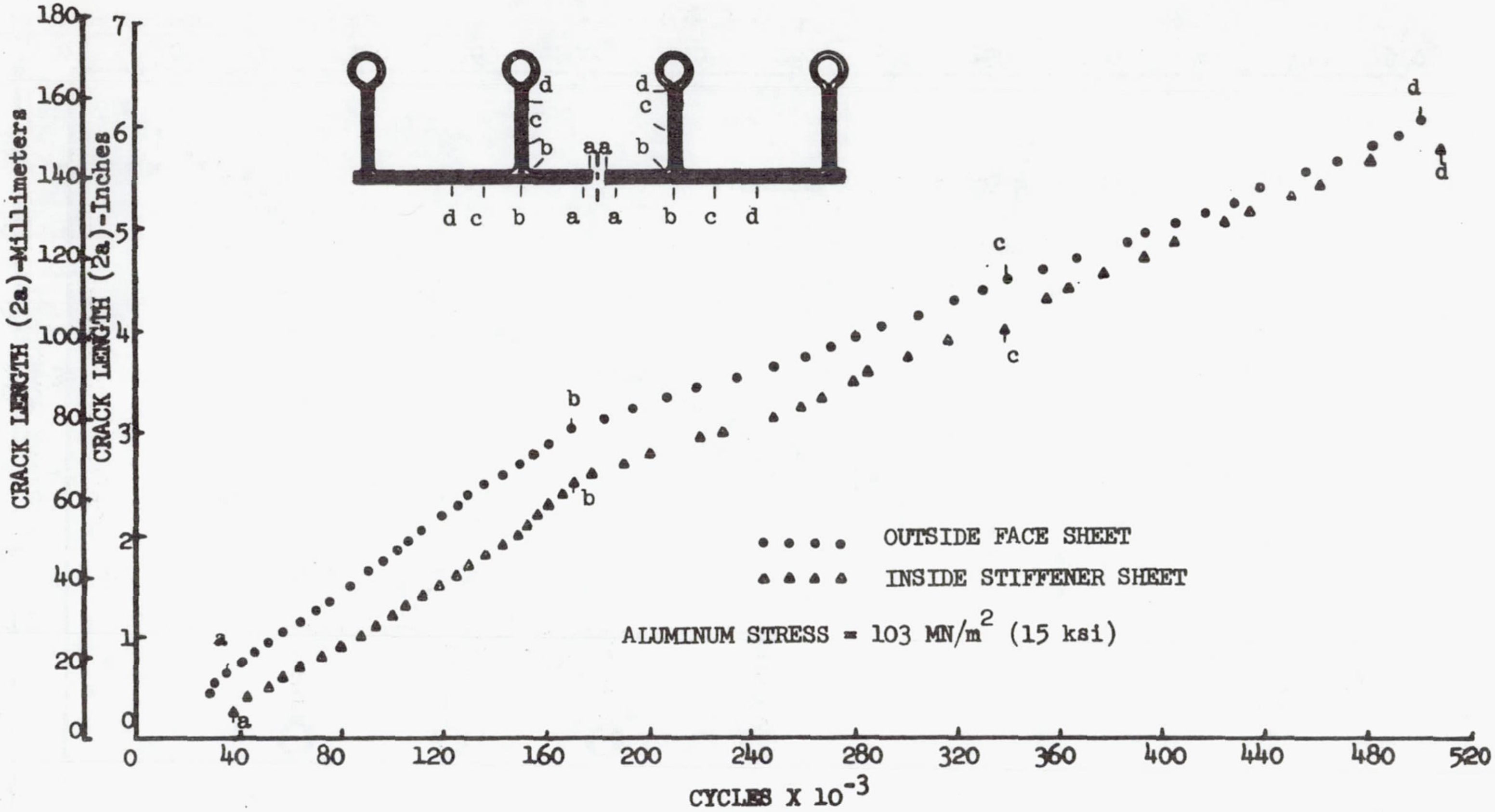


FIGURE 41 MEASURED PRIMARY CRACK LENGTH (2a) VERSUS NUMBER OF CYCLES, PANEL #9C

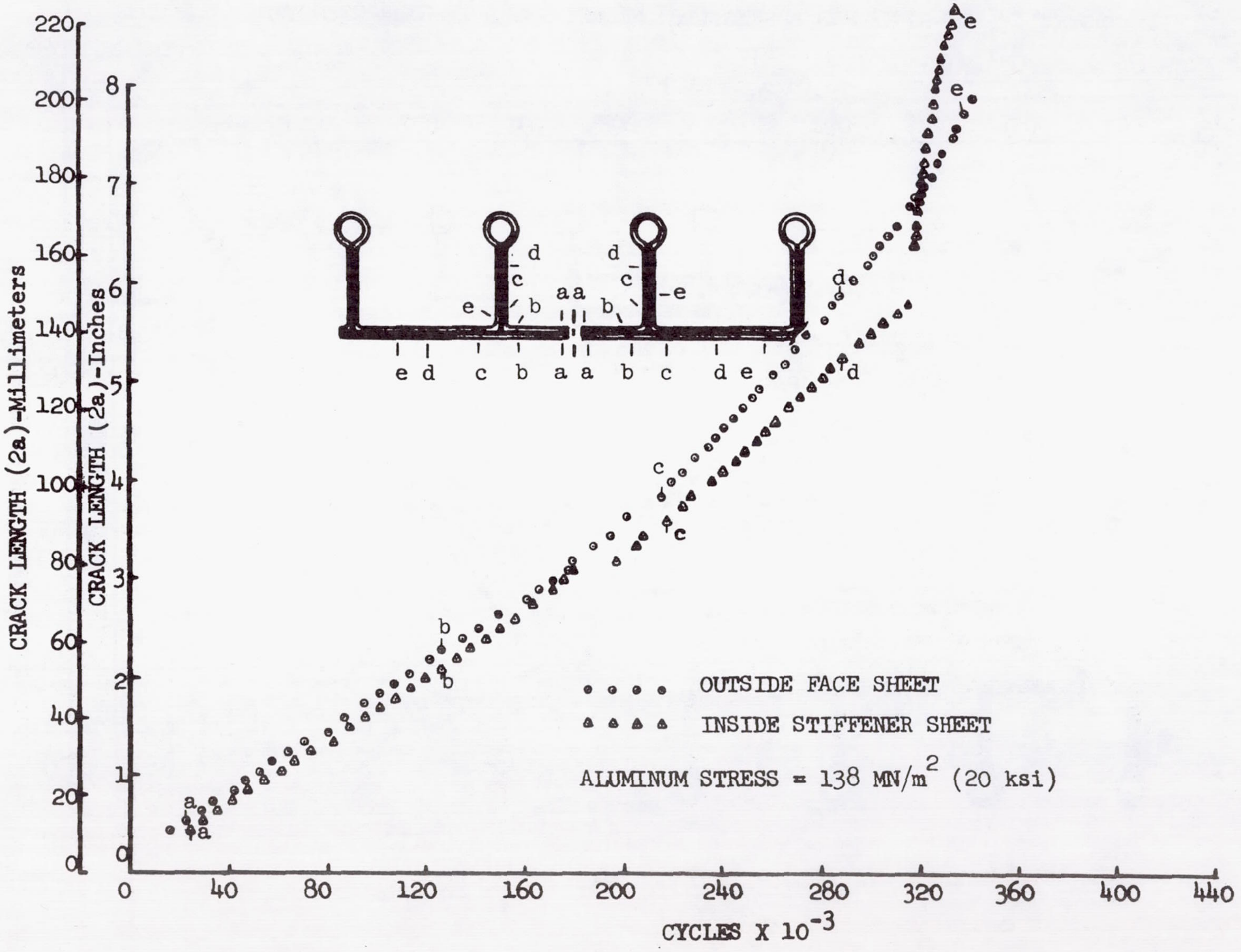


FIGURE 42 MEASURED PRIMARY CRACK LENGTH (2a) VERSUS NUMBER OF CYCLES, PANEL #10C

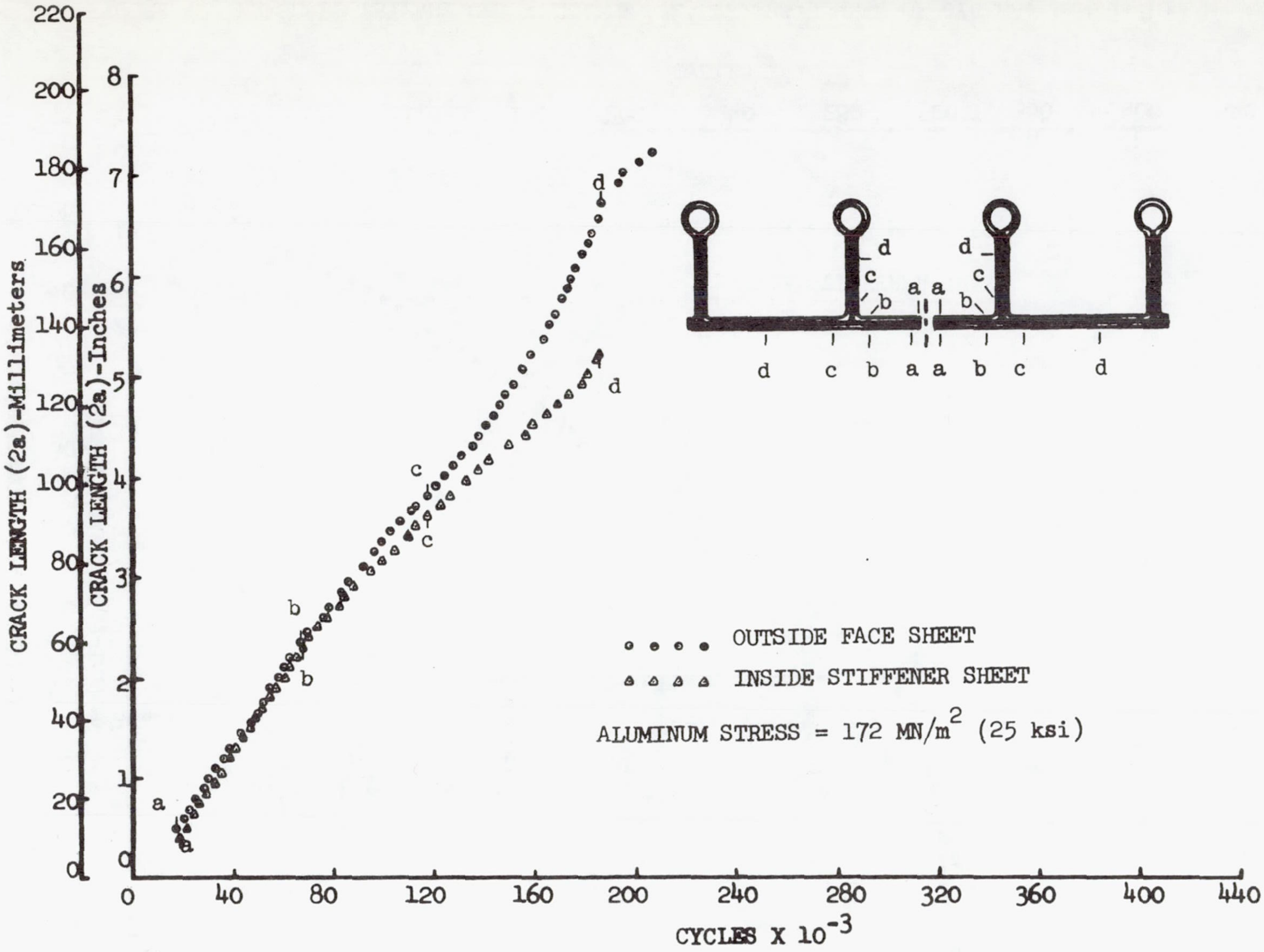


FIGURE 43 MEASURED PRIMARY CRACK LENGTH (2a) VERSUS NUMBER OF CYCLES, PANEL #11C

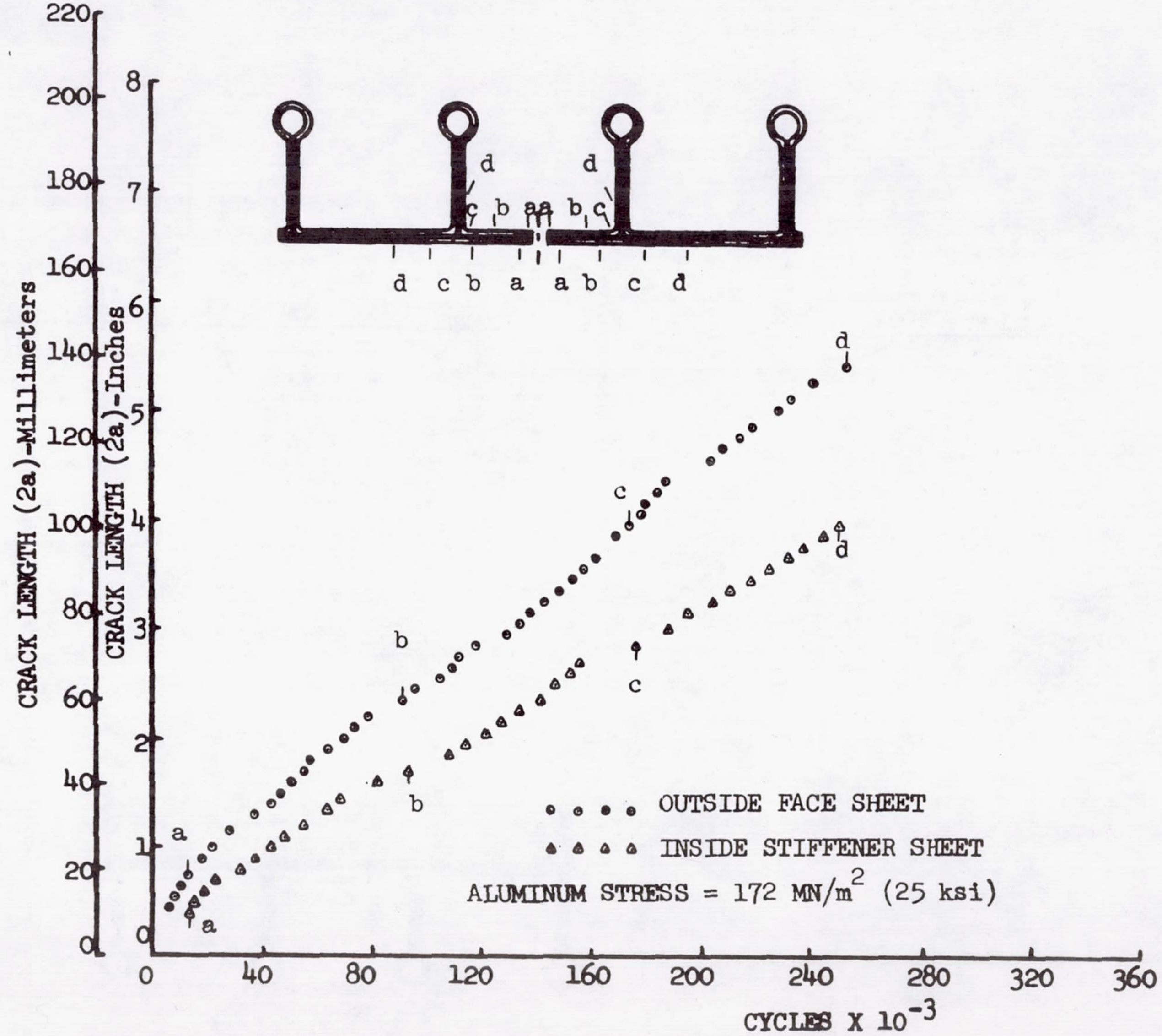


FIGURE 44 MEASURED PRIMARY CRACK LENGTH (2a) VERSUS NUMBER OF CYCLES, PANEL #12C

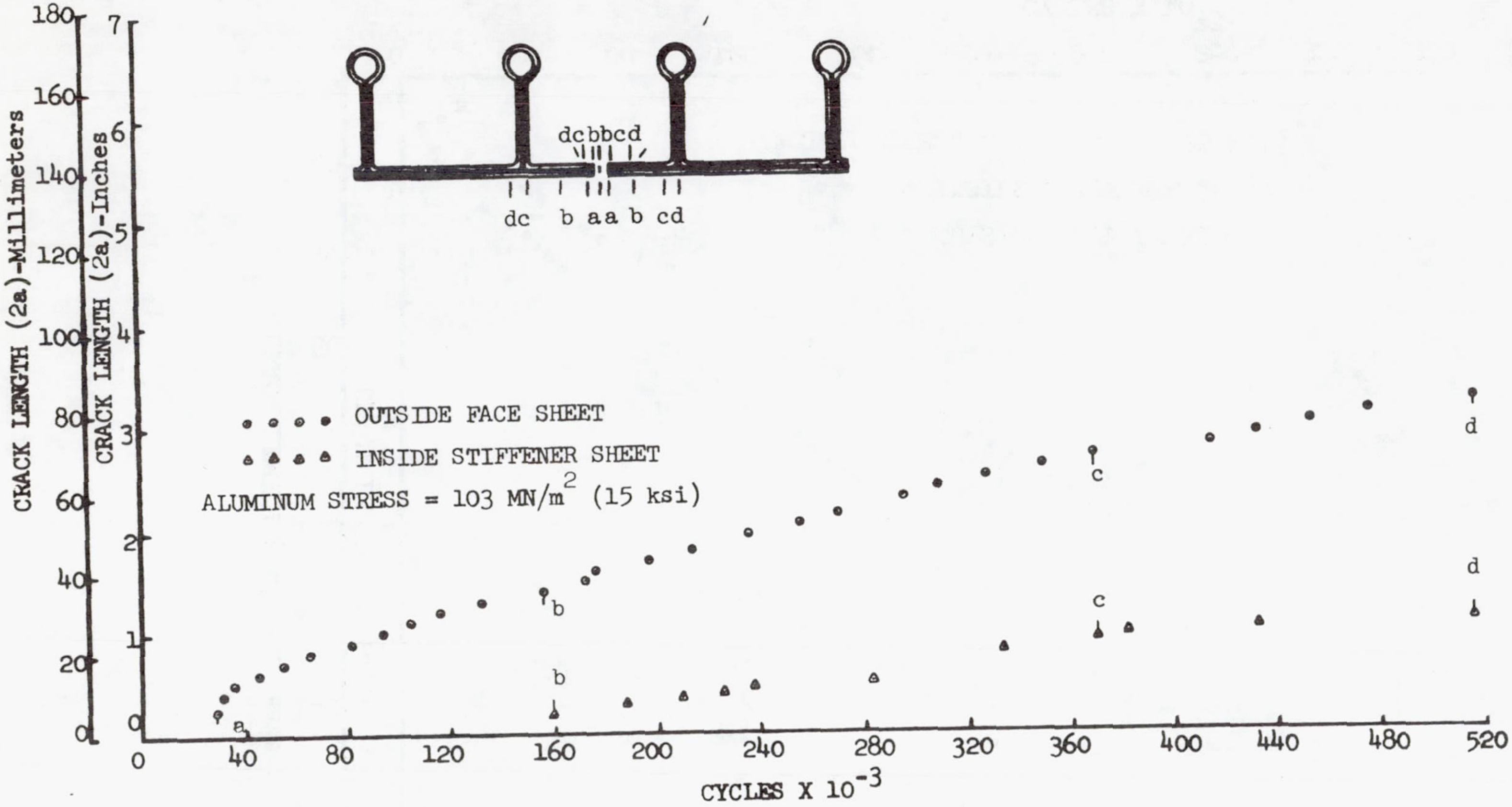


FIGURE 45 MEASURED PRIMARY CRACK LENGTH (2a) VERSUS NUMBER OF CYCLES, PANEL #13C

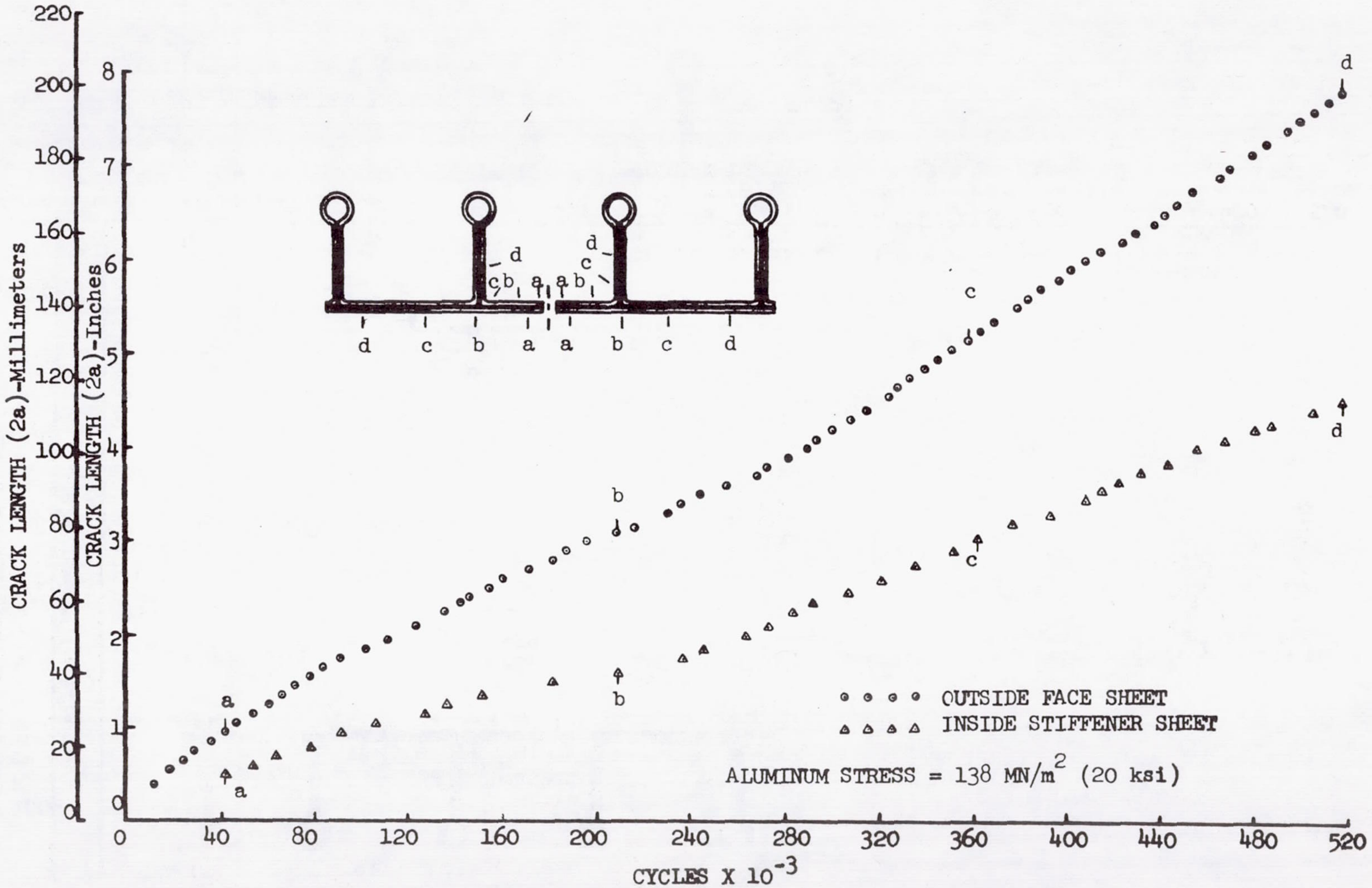


FIGURE 46 MEASURED PRIMARY CRACK LENGTH (2a) VERSUS NUMBER OF CYCLES, PANEL #14C

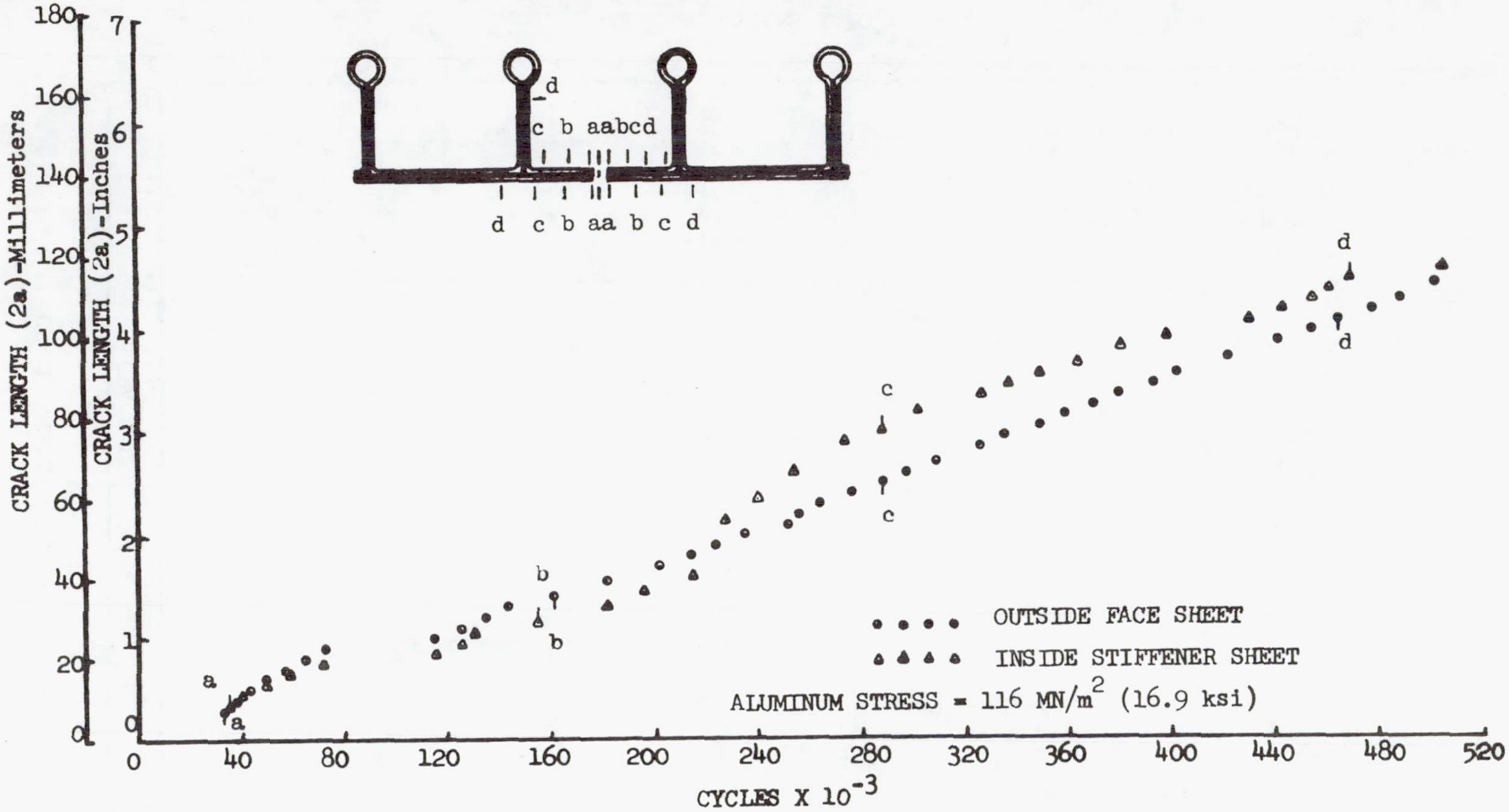


FIGURE 47 MEASURED PRIMARY CRACK LENGTH (2a) VERSUS NUMBER OF CYCLES, PANEL #15C

PANEL RESIDUAL STRENGTH

Objective

The objective of this portion of the program was to determine the remaining residual strength of the composite-metal panels after the metal was significantly cracked.

Approach

After the panels had been cycled and the stiffener and face sheets were significantly cracked, the panels were pulled statically to failure to determine the residual strength. This value of strength was compared to the design limit load to determine if the fatigue cycling had a detrimental effect on the strength of the composite material.

Results and Discussion

Table XVIII gives the results of the residual strength tests. The design limit load was determined by equation (9).

The amount of metal cracked during fatigue cycling varied from 22-53 percent. Panel 6C residual load was not recorded and panels 12C, 13C, and 14C failed under the end fittings through a row of bolt holes. Figure 48 shows that the residual strength of the composite-metal panels generally exceeded the design limit load and thus satisfied the design criteria. However, some degradation of original composite strength is indicated because the residual strength is generally less than the original ultimate strength (150% limit strength).

Conclusions

A composite-reinforced metal panel can be designed to sustain limit load after a significant area of metal has been cracked in fatigue and, at the same time, to be as light as an all-metal panel.

TABLE XVIII

PANEL RESIDUAL STRENGTH

PANEL No.	MAX. FATIGUE STRESS IN METAL		TOTAL CYCLES	% OF METAL CRACKED	COMPOSITE AREA		DESIGN LIMIT LOAD [1]		RESIDUAL STRENGTH		% OF DESIGN LIMIT LOAD
	MN/m^2	(ksi)			mm^2	(in^2)	kN	(lbf x 10^{-3})	kN	(lbf x 10^{-3})	
1C	103	15.0	68,658	47	513.8	.7964 [2]	206.8	46.5	52.2	11.7	25
2C	116	16.9	779,842	41	361.6	.5606	251.8	56.6	223.3	50.2	89
3C	116	16.9	465,606	26	418.0	.6480	291.3	65.5	364.7	82.0	125
4C	116	16.9	304,134	22	361.6	.5606	251.8	56.6	263.8	59.3	105
5C	172	25.0	176,452	23	361.6	.5606	251.8	56.6	302.5	68.0	120
6C	138	20.0	254,394	25	361.6	.5606	251.8	56.6	[3]	[3]	---
7C	103	15.0	1,020,520	36	361.6	.5606	251.8	56.6	539.1	121.0	124
8C	103	15.0	554,529	43	275.0	.4264	271.3	61.0	453.7	102.0	167
9C	103	15.0	631,049	53	237.9	.3689	235.3	52.9	286.9	64.5	122
10C	138	20.0	341,983	53	237.9	.3689	235.3	52.9	276.9	62.3	118
11C	172	25.0	206,476	40	237.9	.3689	235.3	52.9	257.5	57.9	109
12C	172	25.0	252,993	[4]	418.0	.6480	291.3	65.5	253.5	57.0	87
13C	103	15.0	1,853,408	[4]	418.0	.6480	291.3	65.5	371.8	83.6	127
14C	138	20.0	530,897	[4]	418.0	.6480	291.3	65.5	279.3	62.8	96
15C	116	16.9	506,465	28	361.6	.5606	251.8	56.6	351.4	79.0	141

[1] Based on equation (9) and limit stresses in Table I.

[2] All aluminum area.

[3] Residual strength not recorded.

[4] Failed at end fittings outside of test area.

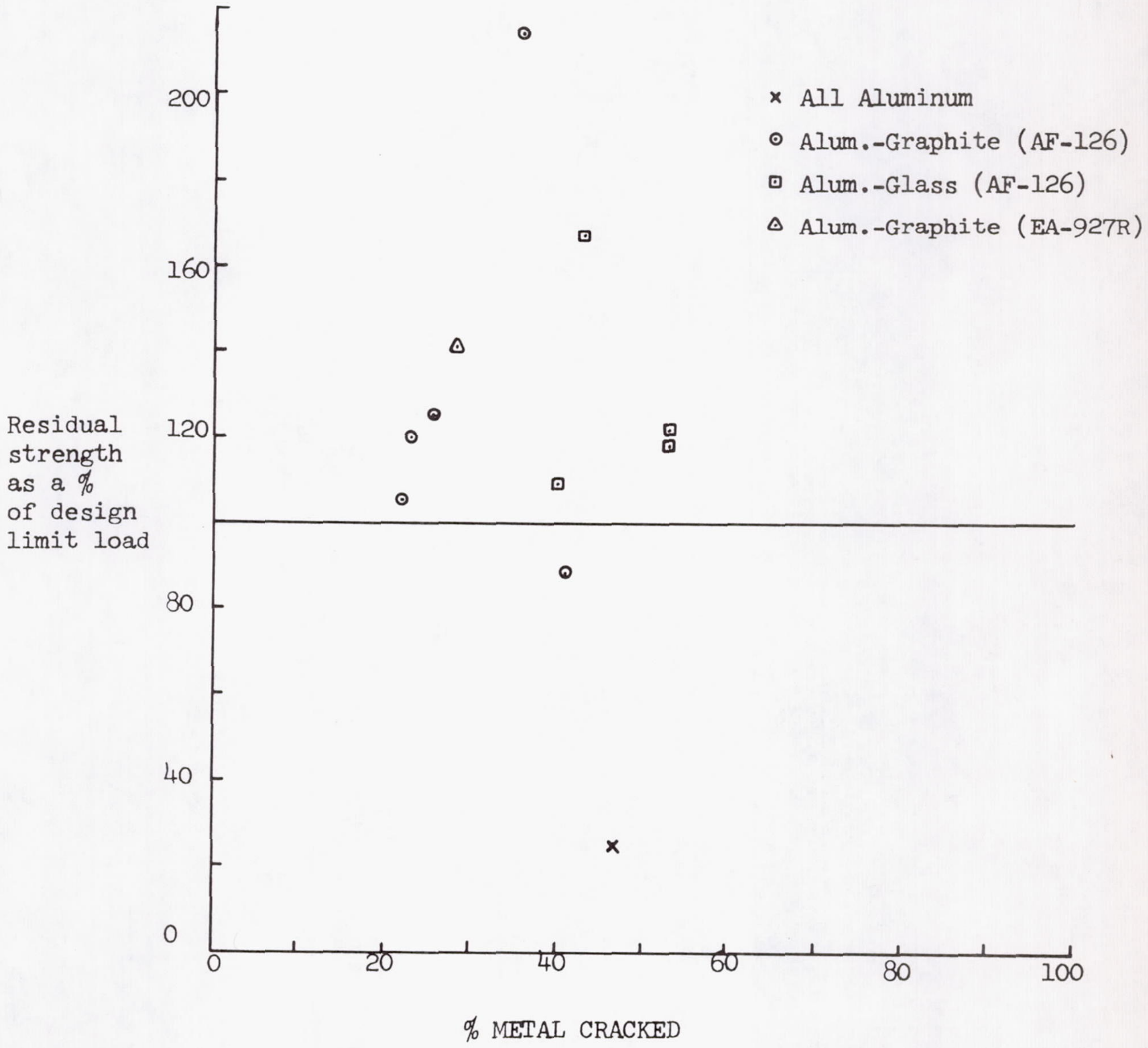


FIGURE 48 PERCENT OF PANEL RESIDUAL STRENGTH vs. PERCENT OF METAL CRACKED IN PANEL

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SUMMARY OF CONCLUSIONS AND RECOMMENDATIONS

The fail-safe design criteria established in this investigation was:

1. The composite material would support the total load at limit stress after the metal had completely failed.

2. The weight of the composite-metal system would be equal to that of an all metal system which would carry the same total load at limit stress.

This criteria produced a stiffness ratio μ of 0.57 for the aluminum-graphite system and 0.29 for the aluminum-glass system. If higher values of stress were allowed to be carried by the composite, after metal failure, then the composite-metal system could weigh much less than an all metal system; however, this produces a lesser degree of fail-safety.

The shear strength of the AF-126 and EA-927R adhesives was equivalent to present values used in aircraft design and were used to bond the composite-reinforced, integrally stiffened metal panels. The EC-1614 paste adhesive could not be used because of the complexity of the panels.

The composite-metal structure was sensitive to static stress concentration effects although a higher average ultimate tensile strength was obtained. However, the stress concentration effects in fatigue is about the same as in the all metal, but because of the better fatigue characteristics of the composite material, the composite-metal system provides extended fatigue life for the same or less weight. The coupon fatigue data showed no significant difference in the fatigue characteristics of the aluminum-graphite system when using either the elevated or room temperature cure adhesive.

The composite-reinforced, integrally stiffened metal panels can be loaded uniformly under constant amplitude fatigue loading. The metal crack growth rates produced by fatigue loading are essentially constant and much slower than that in an all metal structure. The crack growth in the aluminum-graphite system is less than that of the aluminum-glass system for the same gross metal stress and for the composite-metal-adhesives used no significant debonding occurred in the vicinity of the crack. Therefore, for the composite-metal-adhesive systems investigated there was sufficient strength in the system to transfer the load from the metal to the composite when the metal was cracked and maintain its effective fail-safeness.

The amount of metal cracked during fatigue cycling varied from 22-53 percent. The residual strength of the composite-metal panels generally exceeded the design limit load. However, some degradation of original composite strength is indicated because the residual strength is generally less than the original ultimate strength (150% limit strength).

Future studies of composite-reinforced, integrally stiffened metal panels should concentrate on the refinement of the design criteria involving metal-composite thickness relationships required to insure fail-safeness, development of joining techniques suitable for airframe applications, and defining better fracture criteria associated with crack growth and residual strength characteristics.

APPENDIX A

CONVERSION OF SI UNITS TO U. S. CUSTOMARY UNITS

The International System of Units (SI) was adopted by the Eleventh General Conference on Weights and Measures held in Paris in 1960. Conversion factors required for units used herein are given in the following table:

Physical Quantity	SI Unit (*)	Conversion factor (**)	U.S. Customary Unit
Density	kilograms per cubic meter (kg/m^3)	0.3613×10^{-4}	lbm/in^3
Force	newtons (N)	0.2248	lbf
Length	meters (m)	0.3937×10^2	in.
Mass	kilograms (kg)	2.205	lbm.
Stress, Modulus	newtons per sq. meter (N/m^2)	0.145×10^{-6}	ksi = 10^3 lbf/in^2
Temperature	degrees Kelvin (K)	$\frac{9}{5}$ K - 459.67	^{o}F

*Prefixes to indicate multiple of units are as follows:

Prefix	Multiple
mega (M)	10^6
kilo (k)	10^3
milli (m)	10^{-3}

**Multiply value given in SI Unit by conversion factor to obtain equivalent in U. S. Customary Unit.

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APPENDIX B

TEST MATERIALS

The following materials were used to fabricate the test specimens:

Aluminum sheet was alloy 7075-T6 per QQ-A-250/13.

Graphite was obtained from Fothgill/Harvey, pre-preg sheets of 305 mm. (12 in.) wide and 1168 mm. (46 in.) long (ERLA 4617 resin with courtalds fiber).

S-glass was "Scotchply" type 1009-26S and was obtained from the Minnesota Mining and Manufacturing Company.

AF-126 adhesive was obtained from the Minnesota Mining and Manufacturing Company. This is a film adhesive of epoxy resin impregnated into a dacron fiber mat and thickness of 0.127mm (0.005 in.). Liquid primer EC-2320 was used on all surfaces.

Epon 927R adhesive was obtained from the Hysol Division of the Dexter Corporation, Pittsburg, California. This is a film adhesive of room temperature curing epoxy resin impregnated into a type 112 glass scrim cloth. The material thickness is 0.127mm (0.005 in.). Epon 927 surface conditioner is used to prime all surfaces.

EC-1614 adhesive was obtained from Minnesota Mining and Manufacturing Company. This is a paste adhesive of room temperature curing epoxy resin.

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APPENDIX C

TEST SPECIMEN FABRICATION

Two types of test specimens were examined during this program: (1) composite-reinforced metal coupons, and (2) composite-reinforced, integrally stiffened metal panels. The coupon specimens are shown in Figures 3 and 20, and the integrally stiffened test panel is shown in Figure 31.

The fabrication of composite reinforced metal coupons was accomplished as follows: (1) layed-up and cured composite material, (2) bonded aluminum to composite to form sandwich structure, and (3) rough trimmed and machined to final configuration.

The composite reinforced integrally stiffened panels were fabricated as follows: (1) layed-out and formed metal details with the aid of final sizing dies, (2) layed-up and cured composite material, (3) pre-fit composite and aluminum details and bonded, (4) rough trimmed and machined to desired configuration, and (5) attached test fixture to panel to prepare for test. The all metal panels were fabricated as above but bonded without the composite material inserted.

The test specimens used to qualify the shear strength of the bonding adhesives were double lap shear specimens. Several plies of composite were bonded between two pieces of aluminum with a one-half inch over lap. A spacer was inserted between the aluminum for the remaining length and shims were bonded onto the surface of the composite at the other end for griping, see Figure 2. The total specimen width was 25.4 mm. (1.0 in.).

Metal Forming

The results of an investigation preformed under an initial program to determine the most applicable methods for producing the integrally stiffened inner sheet at both low and high manufacturing rates have shown that two basic requirements exist. First, each stiffener leg must be preformed incrementally and secondly, final sizing of the stiffener legs must be accomplished either by incremental forming or final sizing full panels in one operation.

Methods of fabricating the preformed parts are separated into two categories representing low and high production rates. Producing the preform parts at low rates and low volume requires only a simple brake bending operation. This type of operation, although relatively slow, produces close tolerance parts utilizing pre-drilled alignment holes. It was found that variations in springback, bend radii and gage had no significant effect on 7075 aluminum preformed parts since these materials were formed at room temperature in an annealed state and subsequently heat treated.

The final sizing of all integrally stiffened panels scheduled during the proposed program were performed utilizing die and rod inserts. The forming sequence is illustrated by the preformed and final formed panels in Figures C-1 and C-2. The only variation consisted of a spacer placed between the stiffener sections to allow room for composite insertion prior to bonding.

Composite Material Processing

There were two basic composite materials to undergo the processing operation: (1) Courtauld's HT/S graphite pre-impregnated epoxy fiber, and (2) 3 M's 1009-26S glass prepreg. In order to process the integrally stiffened panels and coupons the composite material required two operations: (1) lay-up and (2) autoclave cure.

Lay-up Procedure

(1) Remove composite material from 256°K (0° F) storage. Allow to warm to room temperature before unsealing storage container.
(2) Cut required plies with a sharp knife, taking care not to disorient fibers. Use clean cotton gloves to prevent soiling plies.
(3) Plies shall be cut such that no tow end-to-end splices shall be incorporated in the laminate assembly.
(4) Plies shall be cut such that side-to-side joints (joining of sheets or tape within a ply) are staggered a minimum of 25.4 mm. (1.0 in.) within a thickness of five plies.
(5) Tows shall be kept within $\pm$1-1/2° of the intended orientation.
(6) Side-to-side gaps between plies shall be located no more than 0.38 mm. (.015 in.) apart with no overlap.
(7) Apply nylon peel ply cloth to both sides of laminate.

Autoclave Cure

(1) After lay-up operation vacuum bag composite structure with nylon film and apply suitable bleeding and release system. Locate in autoclave.
(2) Apply vacumm (686 mm. (27 in.) Hg. min). Apply .516 $\pm$ .03 MN/m^2 (75 $\pm$ 5 psi) autoclave pressure and vent to atmosphere.
(3) Cure component as follows:
    (a) Courtauld's HT/S graphite
        1 hour @ 435°K (325° F), .516 MN/m^2 (75 psi)
        1 hour @ 450°K (350° F), .516 MN/m^2 (75 psi)
    (b) 3 M's 1009-26S glass pre-preg.
        1 hour @ 440°K (330° F), .210 MN/m^2 (30 psi)
        4 hours @ 445°K (340° F) post cure in air circulating oven

Following the autoclave cure and machining operations, the composite materials were then ready for bonding.

Ultrasonic Inspection

After the lay-up and cure of the composite material, and before bonding to the metal, the composite was inspected using ultrasonic techniques to check for voids, delaminations, etc. This was accomplished by immersed ultrasonic through transmission techniques. (See Appendix D). This provided an initial record of any defects present in the composite material itself and verified the quality of the initial composite lay-up.

Joining Procedure

Previous development efforts under contract AF 33(615)-3756 have shown good strength to weight indices for the integrally formed panels joined by adhesive bonding. Adhesive bonding was, therefore, selected as the primary joining method for the integrally stiffened panels in this program. This joining procedure included: (1) surface preparation, (2) adhesive application, and (3) final bonding operation.

Surface Preparation

Prior to bonding these integrally stiffened composite panels the materials comprising the sandwich structure was subjected to a thorough cleaning procedure. The following method (per CVA 8-21A) was used for the aluminum preparation:

(1) Vapor degrease in stabilized trichloroethylene.
(2) Alkaline degrease, 15 minutes at 361°K (190° F)
(3) Rinse.
(4) Etch for 12 minutes in a solution of the following composition 339°K (150° F)
    30 pbw distilled H_2O
    10 pbw concentrated H_2SO_4
    4 pbw sodium dichromate
(5) Rinse.
(6) Force dry at 339°K (150° F) for 15 minutes.

The composite materials used in this program were prepared for bonding with the aid of a nylon peel ply cloth in accordance with CVA-207-7-430. This nylon peel ply remained in place prior to adhesive application in order to insure maximum cleanliness.

Adhesive Application

Following surface treatment, a primer coat was applied and allowed to dry. This was then followed with the required adhesive film (AF-126 or EA-927R). The panels were then pre-fitted with the aid of clamps and other holding fixtures. The only difficulty experienced was in placing the composite with adhesive into the stiffener leg area. However, this was easily accomplished with a tool to insure the gap remained in the open position during the composite application.

Bonding Operation

Bonding operations required for joining the integrally stiffened composite panels are essentially the same regardless of the alloy used, differing only in cleaning procedures, and curing cycles employed for the particular materials in use. Based on previous experience, it was anticipated that bonding of the 7075-T6 aluminum composite panels would present no major problem. The elevated temperature adhesive was autoclave processed as shown below:

(1) Form a conventional vacuum bag over assembly with canvas cloth and nylon film; apply clamping device.
(2) Locate bagged panel in autoclave. Apply vacuum [686 mm. Hg. (27 in. Hg) minimum]. Apply .345 MN/m^2 (50 psi) autoclave pressure; vent vacuum bag to atmosphere.
(3) Cure as follows:
$394 \pm 6°K$ ($250 \pm 10° F$) for one hour at .345 MN/m^2 (50 psi).

The room temperature film adhesive (EA-927R) required 24 hrs. at .345 MN/m^2 (50 psi) at ambient temperature, but required no autoclave cure.

Machining

The primary machining requirement in the proposed program was to provide a processing method such that the test articles would sustain a minimum of delamination in the machined area. This was an extremely critical factor in achieving high quality test results. Another consideration was that parallelism be achieved in the test panel ends after test fixture attachment to reduce loading eccentricities which cause premature panel failures.

The principle machining operations encountered in this program included: (1) machining of the composite details, (2) final machining of the test panel periphery, and (3) machining of the coupon radii. All of these processing operations were accomplished on a milling machine utilizing carbide tipped slitting saws, solid carbide end mills and drills while clamped in a holding fixture to provide stabilization of panel details. A template tracing attachment was required for milling the large radii on the coupons. Machining fixtures were also provided to facilitate alignment hole placement in the coupon specimens and in the integrally stiffened composite panel test fixture attachments.

Following FS panel fabrication, aluminum end fittings were machined to size and subsequently adhesively bonded in place to facilitate testing. A tooling jig was prepared to hold the required tolerances while performing the drilling operation. After locating the aluminum test fixture in place, the integrally formed composite panels were then ready for fatigue testing.

FIGURE C-1 TYPICAL INTEGRALLY STIFFENED PREFORM PANEL WITH FINAL SIZING DIES

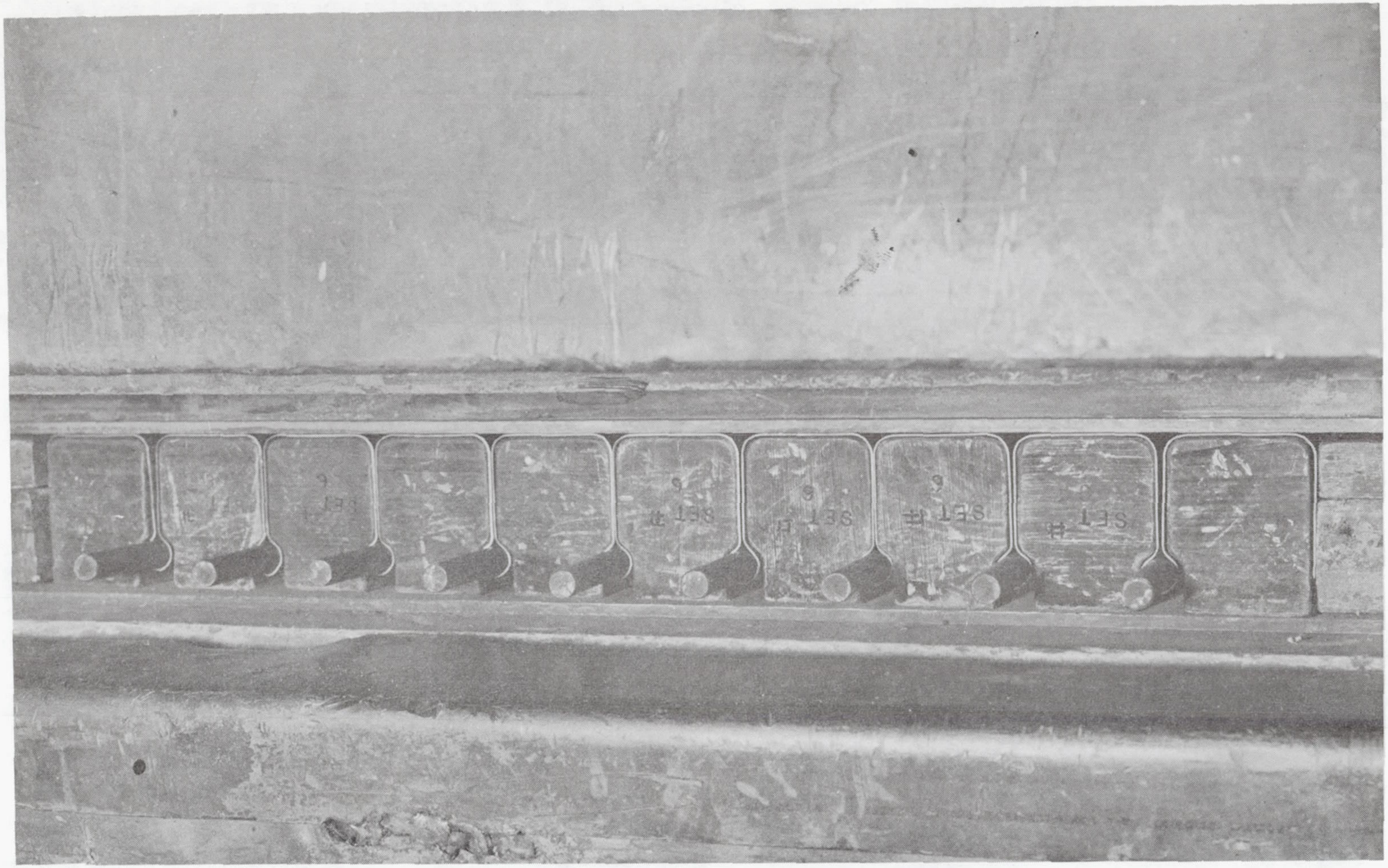

FIGURE C-2 TYPICAL INTEGRALLY STIFFENED PANEL WITH FINAL SIZING DIES CLOSED

APPENDIX D

ULTRASONIC INSPECTION

Ultrasonic through transmission techniques were used to detect voids and delaminations in composite test specimens used in this program. Immersion tests were conducted following fabrication and contact techniques were used during fatigue testing. C-scan recordings were made where possible to produce a permanent record of the bond quality of test specimens used.

Some bond delamination resulted from drilling and was detected and recorded using immersion techniques. Porosity in the bond line was also detected and was found to be more common in room temperature cure adhesive. Contact techniques were used on specimens during fatigue testing. No delamination was detected at fatigue crack locations. This lack of delamination was confirmed by immersion testing after specimen failure. Considering test sensitivity, no delamination was present greater than one eighth of an inch wide at the fatigue crack locations.

Results of contact ultrasonic through transmission techniques are illustrated in Figures D-1 and D-2. As shown in Figure D-1, six regions of bond delamination were discovered on panel #4C by the contact method before crack growth testing. These regions on the outside stiffeners and the right hand interior stiffener were outlined with grease pencil. The crack growth test was conducted with no apparent affect on primary crack growth (compare Figures 34 and 35 to Figure 36), but an extensive amount of secondary cracking was observed on this particular panel (see Figure F-15).

One large region of bond delamination was detected on panel #5C during crack growth testing as shown in Figure D-2. This region was located between the right hand outside and right hand interior stiffeners above the centerline of the panel, as shown. No apparent affect on primary and secondary cracking was observed as a result of this debond region.

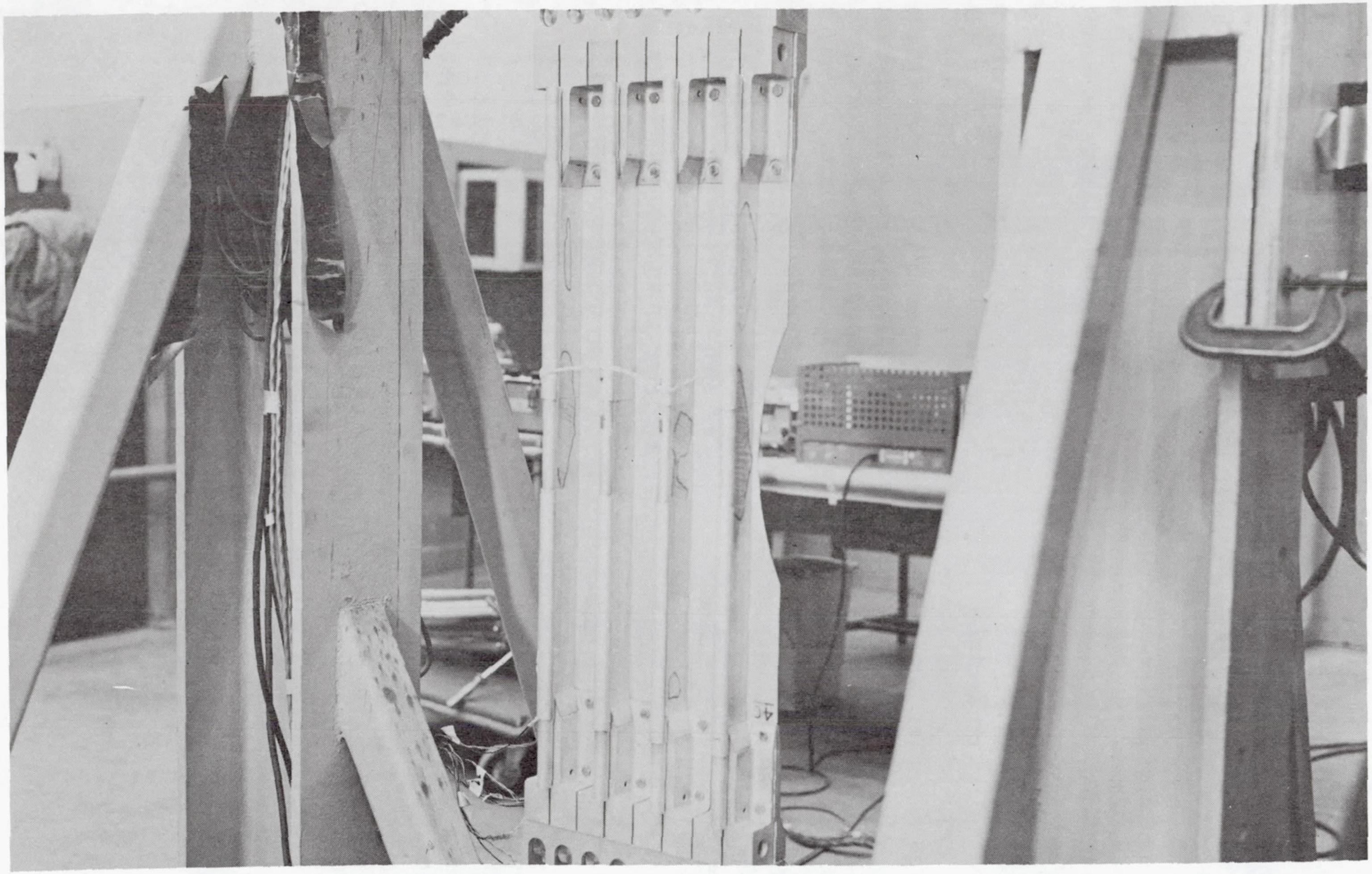

FIGURE D-1 INSIDE STIFFENER SHEET OF PANEL #4C SHOWING REGIONS OF DEBONDING PRIOR TO CRACK GROWTH TEST

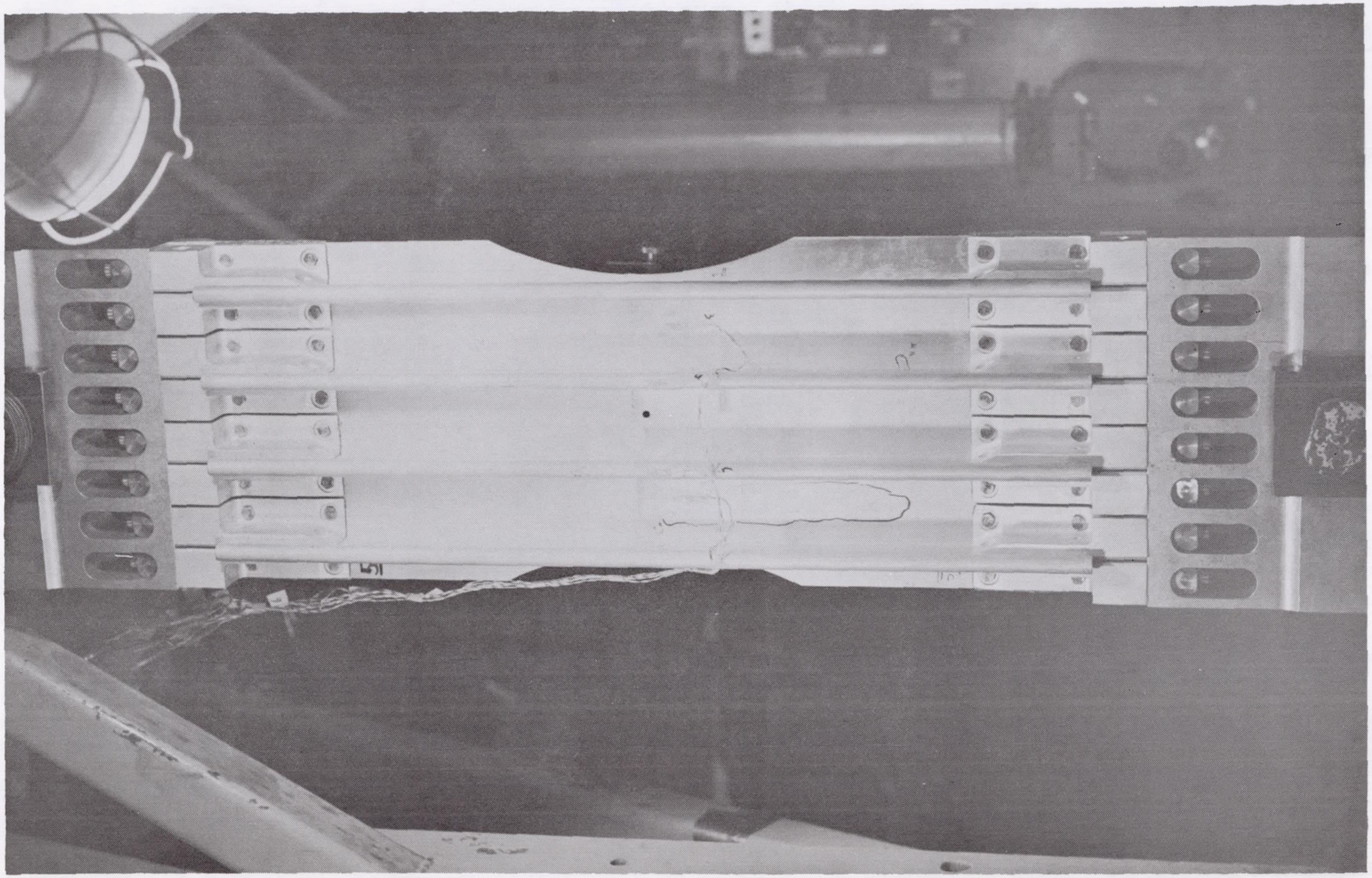

FIGURE D-2 INSIDE STIFFENER SHEET OF PANEL #5C SHOWING A REGION OF DEBONDING THAT WAS DISCOVERED BY ULTRASONIC THROUGH TRANSMISSION INSPECTION DURING CRACK GROWTH TEST

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APPENDIX E

TESTING EQUIPMENT

All lap shear and static tensile coupon tests were conducted on the Reihle screw type test machine. Its load range is from 0 - 712 kN (0 - 160,000 lbf.) and has head speeds of 6.4 to 51 mm/min (0.25 to 2.0 in./min.).

All coupon fatigue tests were conducted on the Baldwin Models SF1-U or SF10-U fatigue machines. These machines have load ranges of 0 - 4.45 kN (0 - 1000 lbf.) and 0 - 44.5 kN (0 - 10,000 lbf.) respectively. The cycling rate is 30 Hz (1800 cpm) with a least count of 1000 cycles. The static load is applied by springs and the alternating load is applied by a rotating weight. The time to obtain the desired load level on the specimen is approximately 10 seconds.

All panel fatigue crack growth tests were conducted in the loading fixture shown in Figure E-1. The hydraulic loading jack had a load range of 0 - 222 kN (0 - 50,000 lbf.). The loading frequency ranged from 1 - 10 Hz (60 - 600 cpm).

The loading jack was controlled and monitored by the closed loop electro-hydraulic test equipment as shown in Figures E-2 and E-3. A paper grid scale with 1.27 mm (0.05 in) increments was attached to the panel in line with the primary cracks in the panel test section. A 30X transit (see Figure E-2) with crossed hair lines and mounted on adjustable stands was used to read crack length increments.

The residual strength tests of the panels were conducted on the Reihle test machine previously mentioned or the 0 - 1.33 MN (0 - 300,000 lbf) Baldwin test machine shown in Figure E-4.

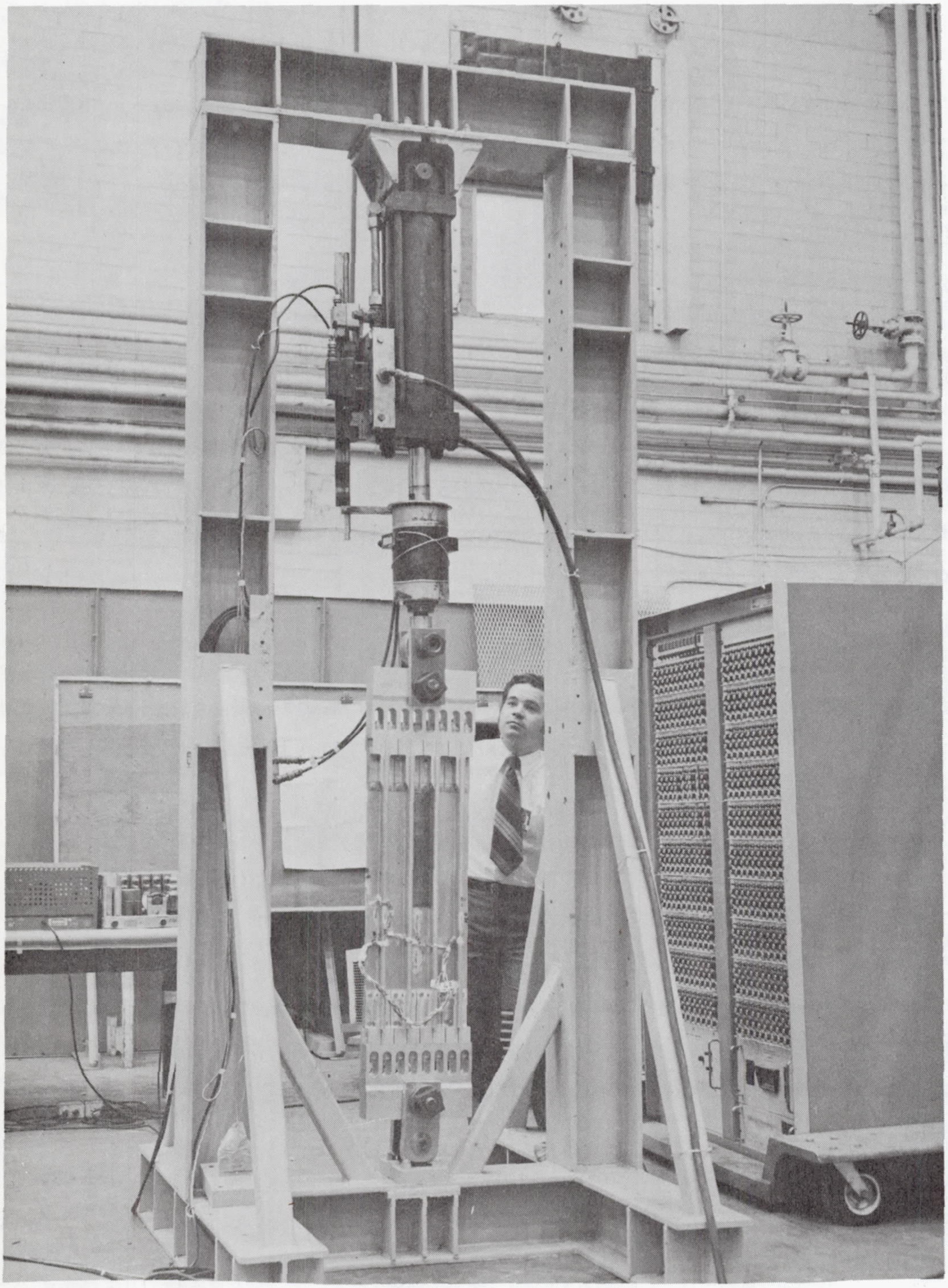

FIGURE E-1 LOADING FIXTURE FOR FATIGUE CRACK GROWTH TESTS

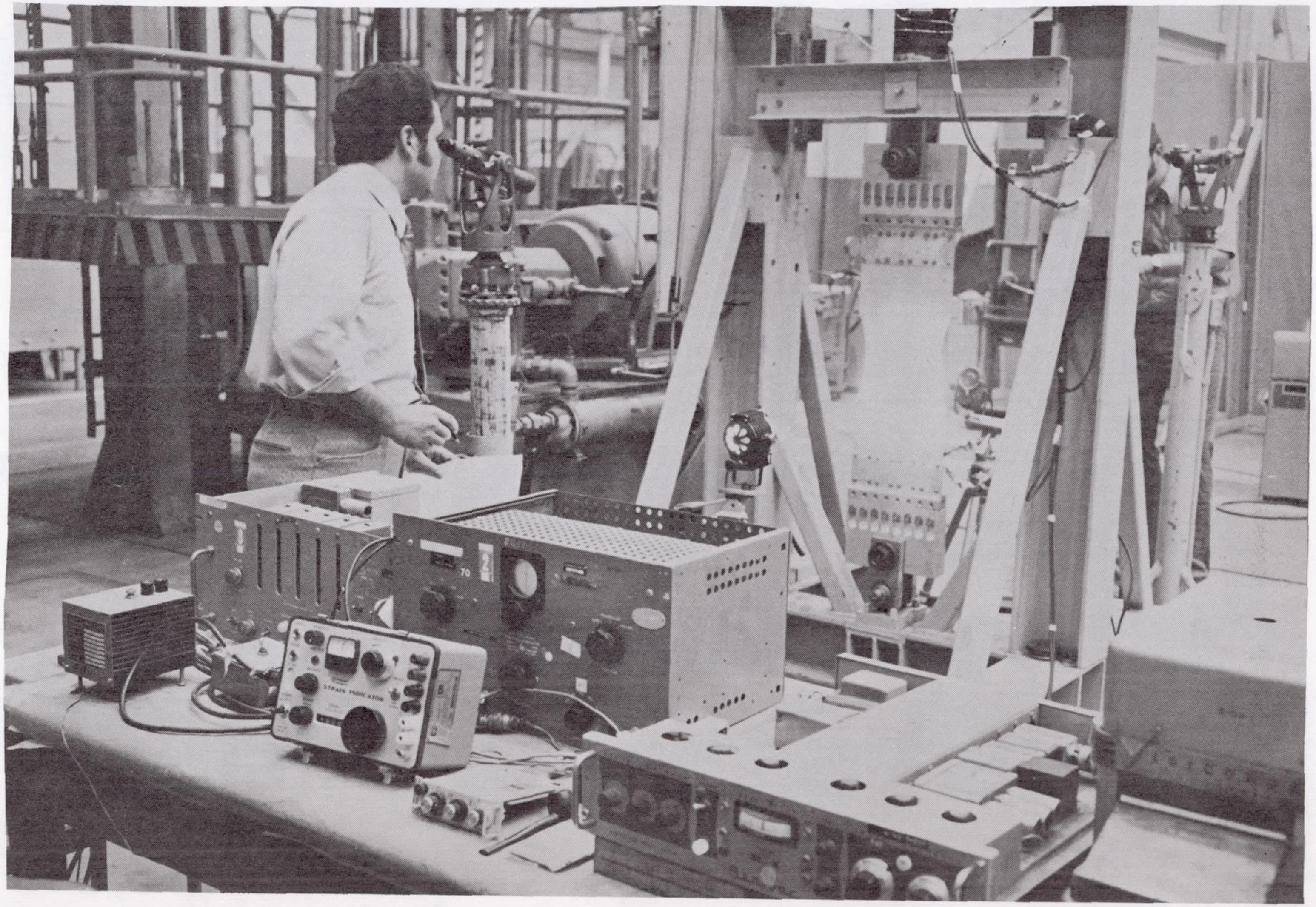

FIGURE E-2 CONTROL AND MONITORING EQUIPMENT FOR FATIGUE CRACK GROWTH TESTS

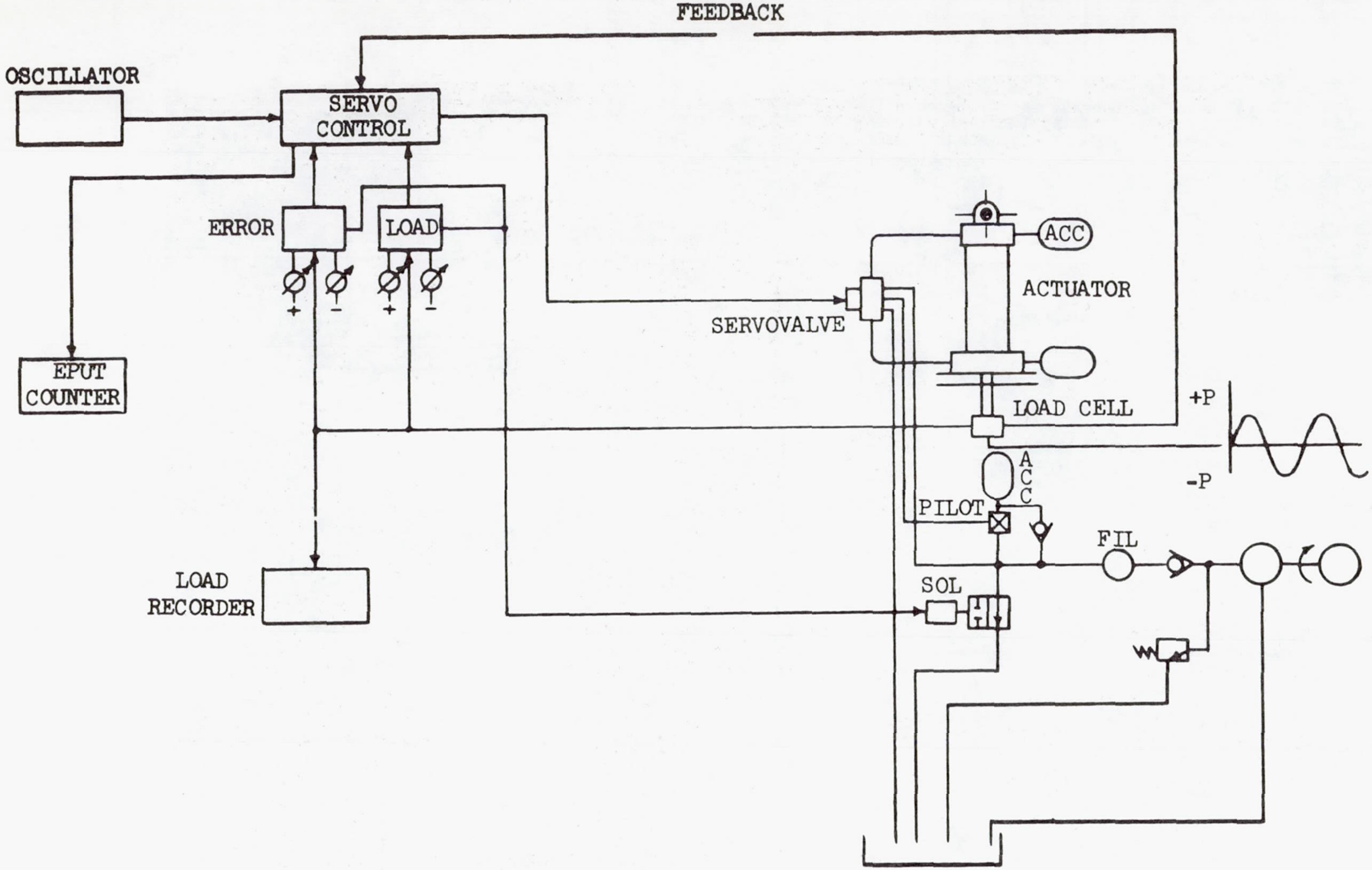

FIGURE E-3 SCHEMATIC DIAGRAM OF
LOAD CONTROL AND MONITORING SYSTEM

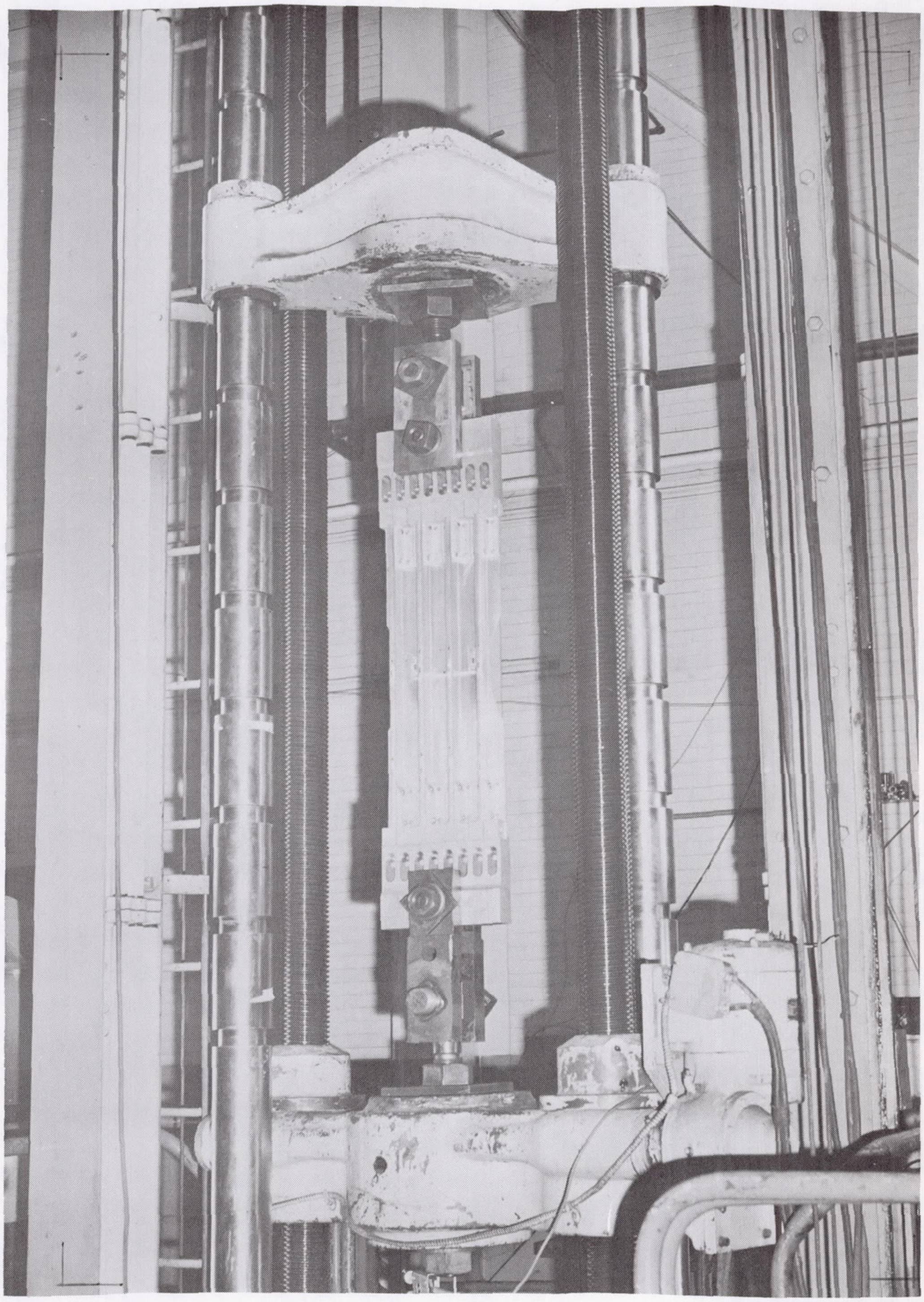

FIGURE E-4 BALDWIN TEST MACHINE PRIOR TO PANEL RESIDUAL STRENGTH TEST

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APPENDIX F

PANEL CRACK GROWTH MEASUREMENT DATA

The purpose of this appendix is to present the individual panel crack growth data. This data includes panel identification, panel photographs, sketches describing secondary crack locations, raw crack growth data, and curves of crack length versus cycles.

Each section of panel crack growth measurement data is identified with panel number, material combination, adhesive, aluminum stress and maximum fatigue load. This data is summarized in Table F-1.

Panel photographs are presented to visually describe the extent of primary and secondary cracking. Primary cracks are defined as those originating at the center quarter inch diameter hole. All other cracks are secondary cracks. (See Figure F-1)

Sketches of secondary crack locations are included to further define secondary cracking. If no secondary cracking occurred then no sketches are included.

Panel crack growth data is presented to describe the progression of all primary cracks and those secondary cracks that are within the test region.

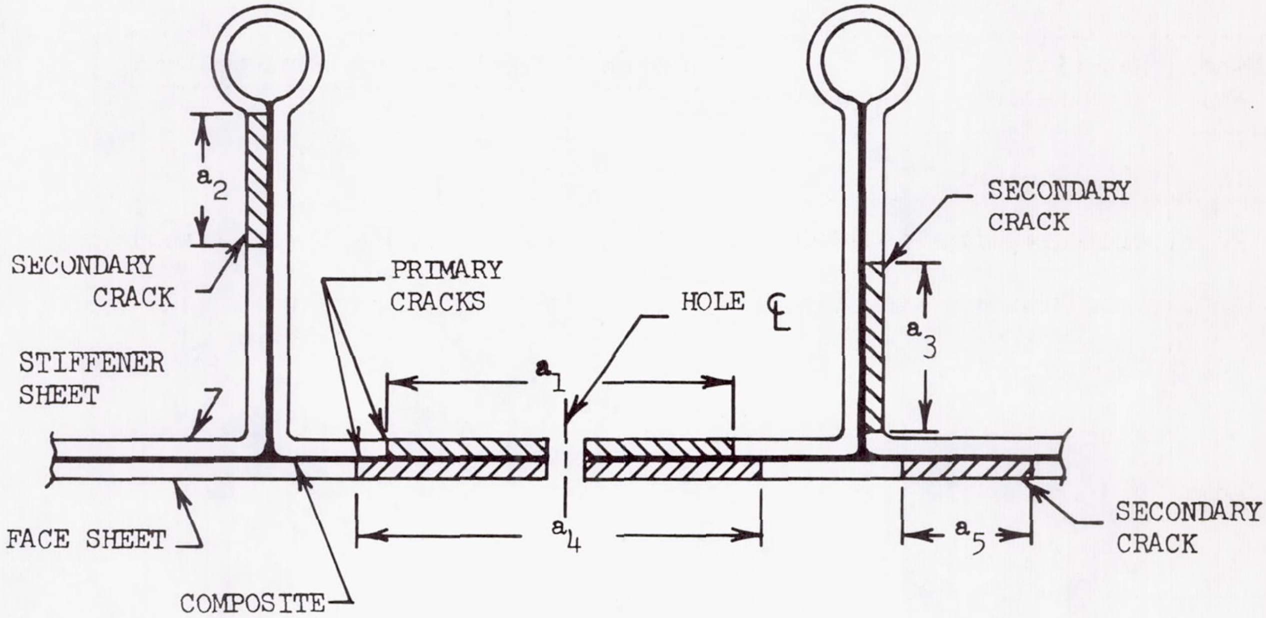
Crack growth curves are included within this appendix. These curves describe the total crack length, primary crack length plus secondary crack lengths and is measured along the panel surface (see Figure F-1).

TABLE F-1

SUMMARY OF PANEL CRACK GROWTH TEST PARAMETERS

Panel No.	Material Combination	Adhesive*	Aluminum Stress		Maximum Fatigue Load	
			MN/m^2	(ksi)	N	(lbf)
1C	All Aluminum	AF-126	103	15	48,930	11,000
2C	Alum-Graphite	AF-126	116	16.9	137,890	31,000
3C	Alum-Graphite	AF-126	116	16.9	155,680	35,000
4C	Alum-Graphite	AF-126	116	16.9	137,890	31,000
5C	Alum-Graphite	AF-126	172	25	200,160	45,000
6C	Alum-Graphite	AF-126	138	20	164,580	37,000
7C	Alum-Graphite	AF-126	103	15	124,540	28,000
8C	Alum.-Glass	AF-126	103	15	84,510	19,000
9C	Alum.-Glass	AF-126	103	15	74,730	16,800
10C	Alum.-Glass	AF-126	138	20	100,080	22,500
11C	Alum.-Glass	AF-126	172	25	124,540	28,000
12C	Alum.-Graphite	EA-927R	172	25	200,160	45,000
13C	Alum.-Graphite	EA-927R	103	15	124,540	28,000
14C	Alum.-Graphite	EA-927R	138	20	168,690	37,925
15C	Alum.-Graphite	EA-927R	116	16.9	144,560	32,500

*AF-126 is cured at 389° F (250° F) and EA-927R is cured at room temperature.



STIFFENER SHEET CRACK LENGTH = $2a = a_1 + a_2 + a_3$

FACE SHEET CRACK LENGTH = $2a = a_4 + a_5$

FIGURE F-1

DEFINITION OF CRACK LENGTH MEASUREMENTS

PANEL #1C

MATERIALS: ALL ALUMINUM

ADHESIVE: AF 126

ALUMINUM STRESS: 103 MN/m^2 (15 ksi)

MAXIMUM FATIGUE LOAD: 48,930N (11,000 lbf)

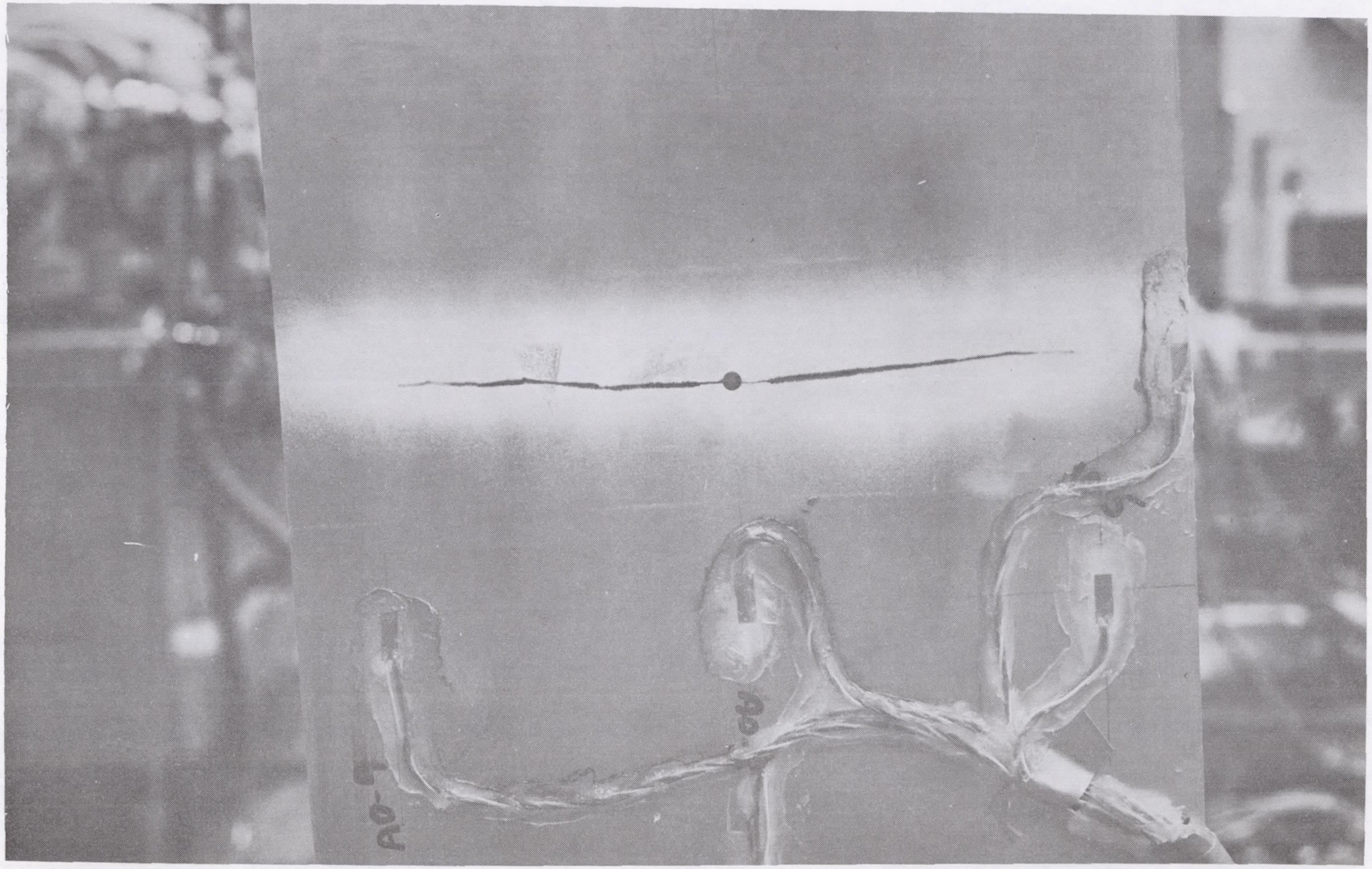


FIGURE F-2 OUTSIDE FACE SHEET AFTER CRACK GROWTH TEST - PANEL #1C

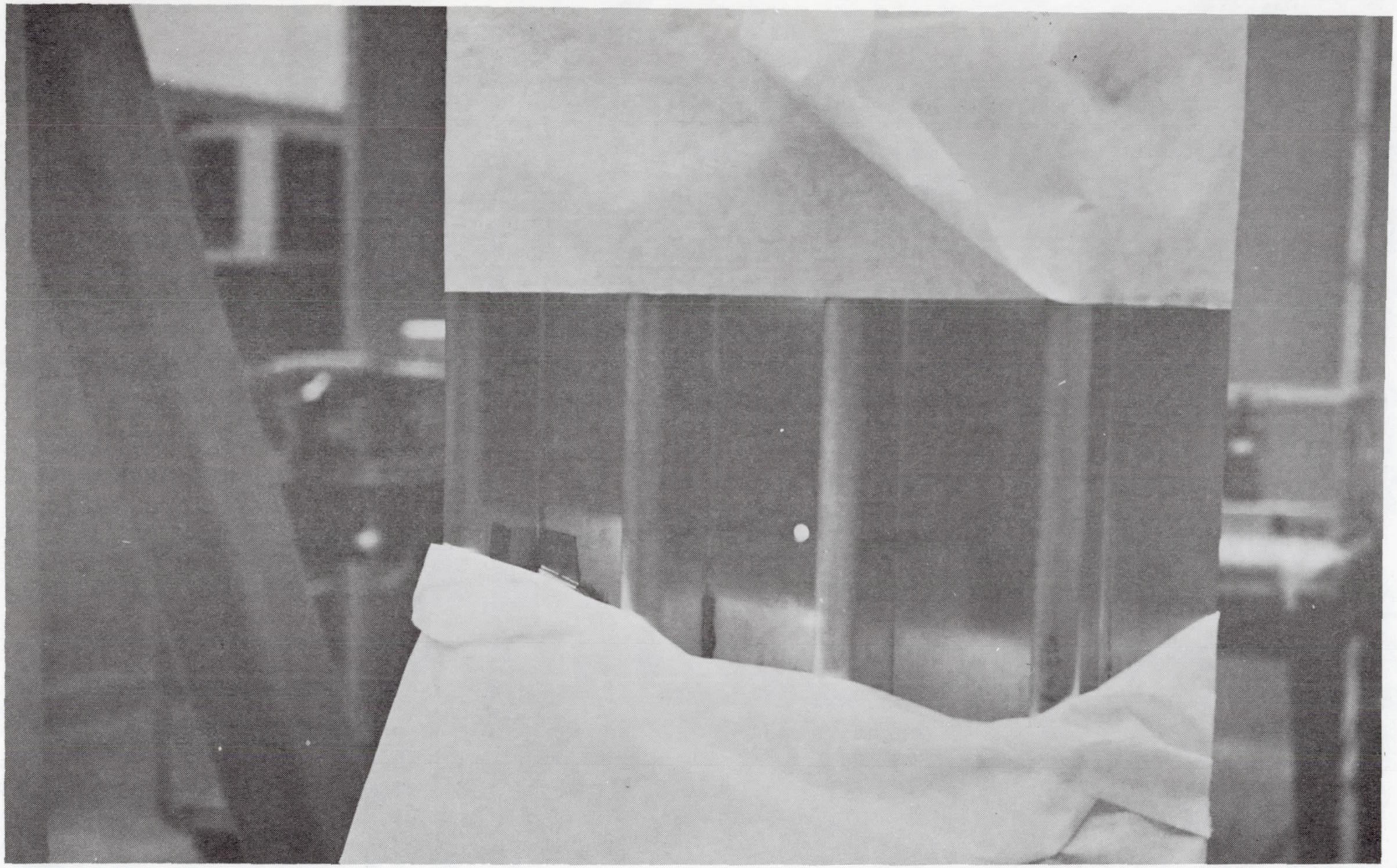


FIGURE F-3 INSIDE STIFFENER SHEET AFTER CRACK GROWTH TEST - PANEL #1C

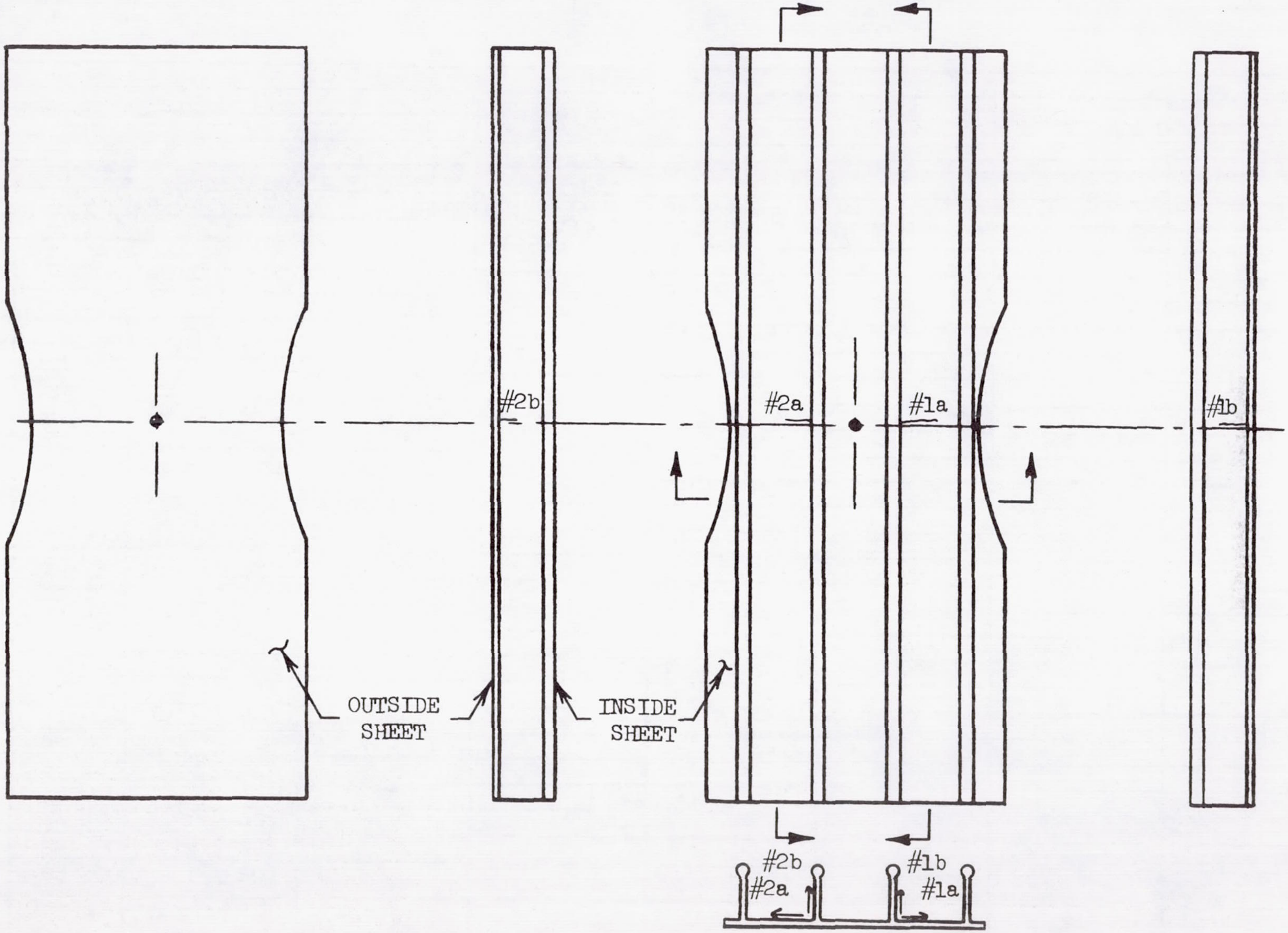


FIGURE F-4 SECONDARY CRACK LOCATIONS
ALL ALUMINUM PANEL #1C

Panel No. 1C		Primary Crack Lengths millimeters (inches)				Secondary Crack Lengths millimeters (inches)		
Cycle Rate	No. of Cycles	L/H Outside	R/H Outside	L/H Inside	R/H Inside			
5 Hz	23,500	5.1 (.20)			5.1 (.20)			
	26,300	6.4 (.25)			6.4 (.25)			
	27,400	7.6 (.30)						
	28,000				7.6 (.30)			
	29,100	8.9 (.35)						
	29,300				8.9 (.35)			
	30,000	10.2 (.40)						
	30,300				10.2 (.40)			
	30,700				11.4 (.45)			
	31,100	11.4 (.45)						
	31,389	12.7 (.50)			12.7 (.50)			
	33,389	14.0 (.55)			14.0 (.55)			
	34,389		6.4 (.25)					
	34,889			6.4 (.25)				
	35,389	15.2 (.60)	7.6 (.30)					
	35,689				16.5 (.65)			
	36,189			8.9 (.35)				
	36,789			10.2 (.40)				
	36,889	17.8 (.70)	10.2 (.40)		17.8 (.70)			
	37,489		11.4 (.45)					
	37,889	19.0 (.75)						
	38,189				19.0 (.75)			
	38,289		12.7 (.50)	12.7 (.50)				
	38,589	20.3 (.80)						
	38,789		15.2 (.60)					
	39,189			14.0 (.55)				
	39,389	22.9 (.90)			21.6 (.85)			
	39,589		16.5 (.65)					
	40,389		17.8 (.70)					
	40,489			16.5 (.65)				
	40,889	25.4 (1.00)						
5 Hz	40,989		19.0 (.75)					

Panel No. 1C		Primary Crack Lengths millimeters (inches)				Secondary Crack Lengths millimeters (inches)		
Cycle Rate	No. of Cycles	L/H Outside	R/H Outside	L/H Inside	R/H Inside			
5 Hz	41,589	26.7 (1.05)						
	41,689			17.8 (.70)	24.1 (.95)			
	42,389		21.6 (.85)					
	42,589				25.4 (1.00)			
	42,789	29.2 (1.15)						
	42,989			19.0 (.75)				
	43,289		22.9 (.90)					
	43,689	30.5 (1.20)						
	44,289		25.4 (1.00)					
	44,389	31.8 (1.25)			27.9 (1.10)			
	44,789			21.6 (.85)				
	45,389		27.9 (1.10)					
	46,189			22.9 (.90)				
	46,389				30.5 (1.20)			
	46,889		29.2 (1.15)					
	47,389	34.3 (1.35)						
	48,589			25.4 (1.00)				
	48,689				33.0 (1.30)			
	48,889		31.8 (1.25)					
	51,389	36.8 (1.45)	33.0 (1.30)	27.9 (1.10)				
	52,389				35.6 (1.40)			
	53,389				36.8 (1.45)			
	54,089			30.5 (1.20)				
	54,389	38.1 (1.50)	35.6 (1.40)					
	55,389			33.0 (1.30)				
	55,889		36.8 (1.45)					
	57,742	40.6 (1.60)	39.4 (1.55)	38.1 (1.50)	39.4 (1.55)			
	58,489		40.6 (1.60)					
	58,589			39.4 (1.55)				
	59,189				40.6 (1.60)			
	59,289	41.9 (1.65)						
5 Hz	59,589		41.9 (1.65)					

Panel No. 1C		Primary Crack Lengths millimeters (inches)				Secondary Crack Lengths millimeters (inches)		
Cycle Rate	No. of Cycles	L/H Outside	R/H Outside	L/H Inside	R/H Inside	#1a Secondary	#1b Secondary	#2a Secondary
5 Hz	60,489			40.6 (1.60)				
5 Hz	65,889	44.4 (1.75)	44.4 (1.75)					
4 Hz	66,389			41.9 (1.65)	43.2 (1.70)			
4 Hz	67,189	45.7 (1.80)						
4 Hz	68,437	69.8 (2.75)	49.5 (1.95)	47.0 (1.85)	61.0 (2.40)	31.8 (1.25)	24.1 (.95)	11.4 (.45)
.25 Hz	68,440							
	68,467							12.7 (.50)
	68,469					34.3 (1.35)		
	68,477	71.1 (2.80)						
	68,484		50.8 (2.00)					
	68,497			48.3 (1.90)				
	68,500	72.4 (2.85)						
	68,510							14.0 (.55)
	68,521	73.7 (2.90)						
	68,525						25.4 (1.00)	
	68,527			49.5 (1.95)				
	68,529		52.1 (2.05)					
	68,544					36.8 (1.45)		
	68,545	74.9 (2.95)						
	68,549				63.5 (2.50)			
	68,550						26.7 (1.05)	
	68,552							15.2 (.60)
	68,556		53.3 (2.10)					
	68,571	76.2 (3.00)						
	68,579		54.6 (2.15)					
	68,581			50.8 (2.00)				
	68,590	77.5 (3.05)						
	68,593					39.4 (1.55)		
	68,595						27.9 (1.10)	
	68,606		55.9 (2.20)	52.1 (2.05)				
	68,607							19.0 (.75)
.25 Hz	68,609	78.7 (3.10)						

Panel No. 1C		Secondary Crack Lengths millimeters (inches)						
Cycle Rate	No. of Cycles	#2b Secondary						
5 Hz	60,489							
5 Hz	65,889							
4 Hz	66,389							
4 Hz	67,189							
4 Hz	68,437	6.4 (.25)						
.25 Hz	68,440	8.9 (.35)						
	68,467	10.2 (.40)						
	68,469							
	68,477							
	68,484							
	68,497							
	68,500							
	68,510	11.4 (.45)						
	68,521							
	68,525							
	68,527							
	68,529							
	68,544							
	68,545							
	68,549							
	68,550	12.7 (.50)						
	68,552							
	68,556							
	68,571							
	68,579							
	68,581	14.0 (.55)						
	68,590							
	68,593							
	68,595							
	68,606							
	68,607							
.25 Hz	68,609							

Panel No. 1C		Primary Crack Lengths millimeters (inches)				Secondary Crack Lengths millimeters (inches)		
Cycle Rate	No. of Cycles	L/H Outside	R/H Outside	L/H Inside	R/H Inside	#1a Secondary	#1b Secondary	#2a Secondary
.25 Hz	68,614	80.0 (3.15)						
↑	68,618				66.0 (2.60)			
	68,621	81.3 (3.20)						
	68,624						29.2 (1.15)	
	68,627		57.2 (2.25)					
	68,632	82.6 (3.25)				45.7 (1.80)		
	68,637	83.8 (3.30)						
	68,639		58.4 (2.30)					
	68,640			53.3 (2.10)				
	68,646				67.3 (2.65)			
	68,647	82.6 (3.35)						
	68,652					48.3 (1.90)		
	68,653							22.9 (.90)
↓	68,656	86.4 (3.40)						
.25 Hz	68,658		59.7 (2.35)					
Final Crack Lengths		86.4 (3.40)	59.7 (2.35)	53.3 (2.10)	67.3 (2.65)	48.3 (1.90)	29.2 (1.15)	22.9 (.90)

Residual Strength = 52,220N (11,740 lbf)

Panel No. 1C		Secondary Crack Lengths millimeters (inches)						
Cycle Rate	No. of Cycles	#2b Secondary						
.25 Hz	68,614							
	68,618							
	68,621							
	68,624	15.2 (.60)						
	68,627							
	68,632							
	68,637							
	68,639							
	68,640							
	68,646							
	68,647	16.5 (.65)						
	68,652							
	68,653							
	68,656							
.25 Hz	68,658							
Final Crack Lengths		16.5 (.65)						

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PANEL #2C

MATERIALS: ALUMINUM-GRAPHITE

ADHESIVE: AF 126

ALUMINUM STRESS: 116 MN/m^2 (16.9 ksi)

MAXIMUM FATIGUE LOAD: 137,890N (31,000 lbf)

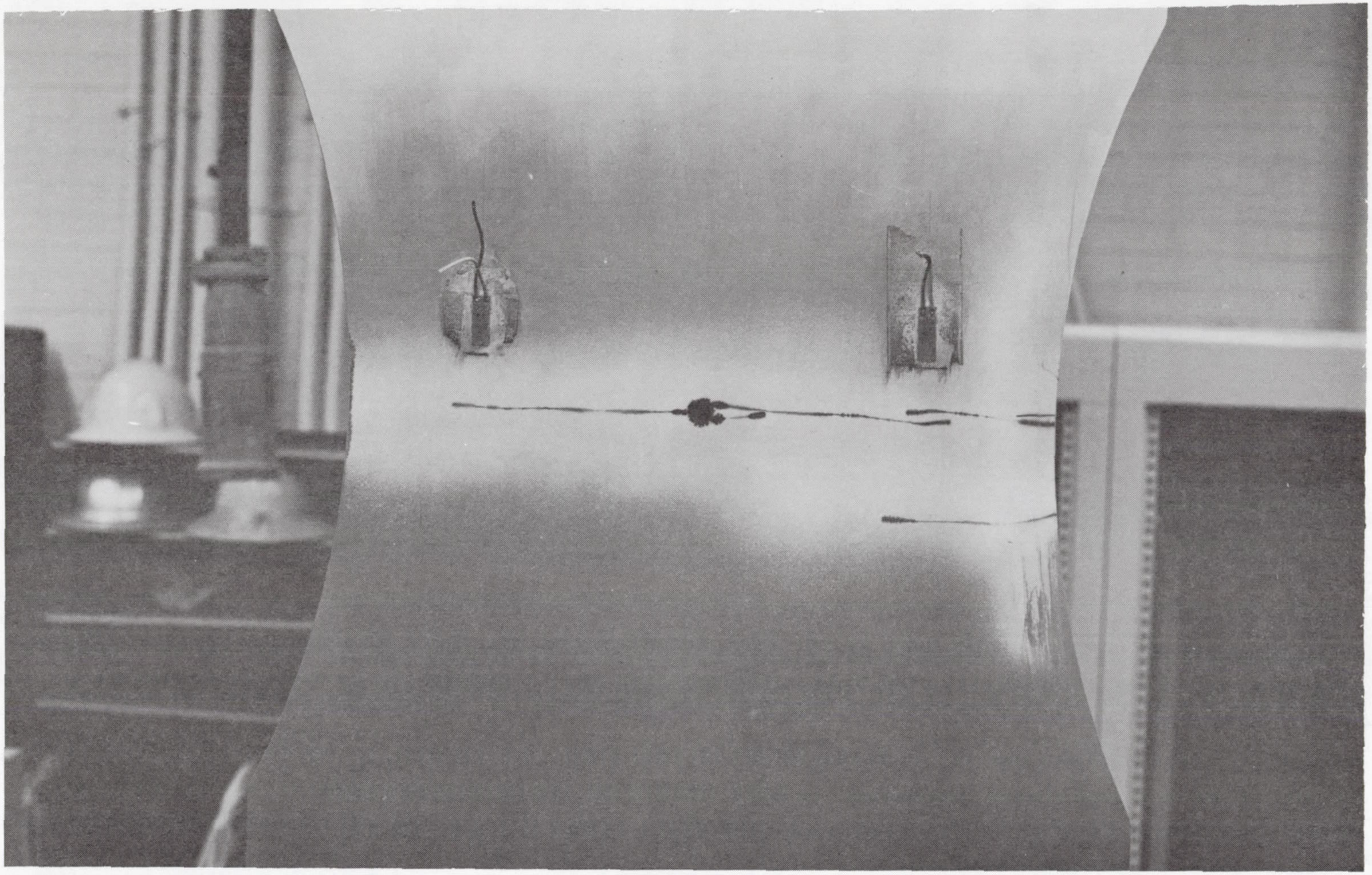

FIGURE F-5 OUTSIDE FACE SHEET AFTER CRACK GROWTH TEST - PANEL #2C

FIGURE F-6 INSIDE STIFFENER SHEET AFTER CRACK GROWTH TEST - PANEL #2C
(LEFT OF CENTERLINE)

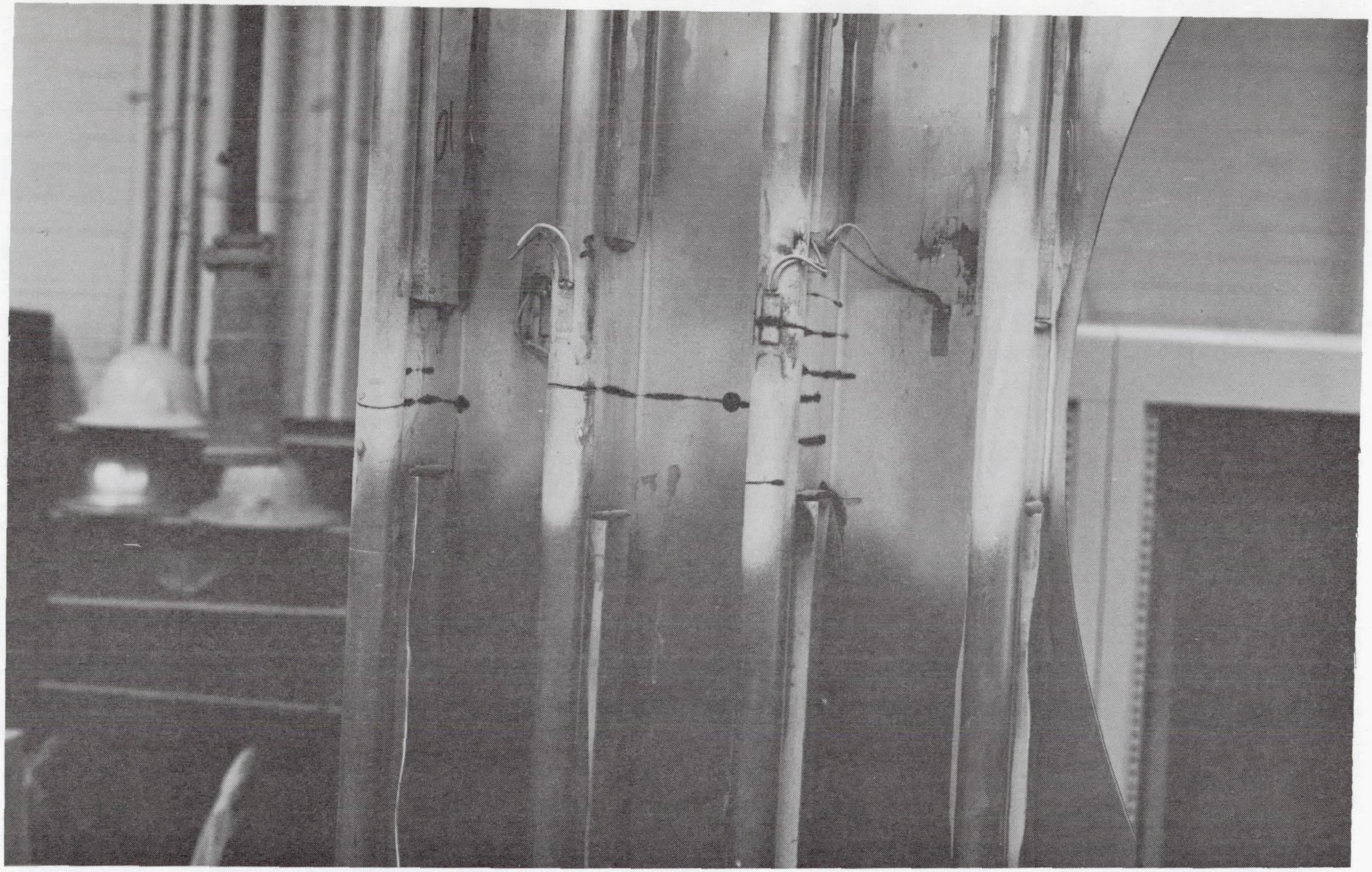

FIGURE F-7 INSIDE STIFFENER SHEET AFTER CRACK GROWTH TEST - PANEL #2C (RIGHT OF CENTERLINE)

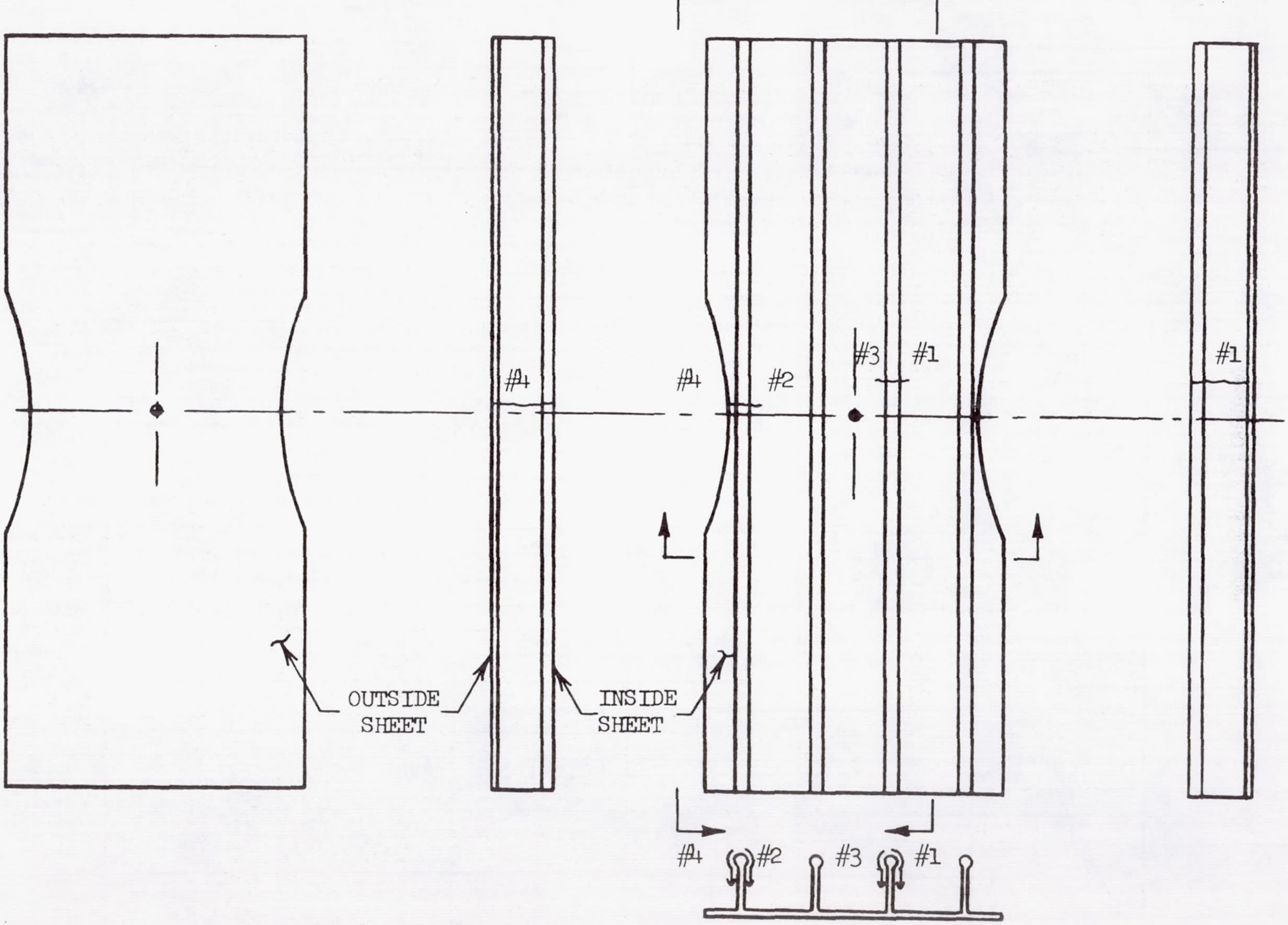

FIGURE F-8 SECONDARY CRACK LOCATIONS
ALUMINUM-GRAPHITE PANEL #2C

Panel No. 2C		Primary Crack Lengths millimeters (inches)				Secondary Crack Lengths millimeters (inches)		
Cycle Rate	No. of Cycles	L/H Outside	R/H Outside	L/H Inside	R/H Inside			
10 Hz	50,350	Initiation	Initiation					
5 Hz	54,166	5.1 (.20)	5.1 (.20)					
	58,266	6.4 (.25)						
	60,766		6.4 (.25)	Initiation				
	65,166	7.6 (.30)						
	65,666			5.1 (.20)				
	67,466		7.6 (.30)					
	68,766				Initiation			
	70,866			6.4 (.25)				
	73,166	8.9 (.35)						
	74,966				5.1 (.20)			
	76,966		8.9 (.35)					
5 Hz	78,366			7.6 (.30)				
9 Hz	81,066	10.2 (.40)						
	81,866				6.4 (.25)			
	82,966		10.2 (.40)					
	86,166			8.9 (.35)				
	88,566				7.6 (.30)			
	89,666	11.4 (.45)						
	90,966		11.4 (.45)					
	93,966			10.2 (.40)				
	97,066				8.9 (.35)			
	98,066	12.7 (.50)						
	102,866			11.4 (.45)				
	103,066		12.7 (.50)					
	108,766	14.0 (.55)						
	109,166				10.2 (.40)			
	112,666		14.0 (.55)					
	113,766			12.7 (.50)				
	120,566	15.2 (.60)						
	121,366				11.4 (.45)			
9 Hz	124,866		15.2 (.60)					

Panel No. 2C		Primary Crack Lengths millimeters (inches)				Secondary Crack Lengths millimeters (inches)		
Cycle Rate	No. of Cycles	L/H Outside	R/H Outside	L/H Inside	R/H Inside			
9 Hz	124,966			14.0 (.55)				
	131,466	16.5 (.65)						
	133,366		16.5 (.65)					
	134,466				12.7 (.50)			
	136,366			15.2 (.60)				
	147,538	17.8 (.70)	17.8 (.70)					
	150,338			16.5 (.65)				
	151,238				14.0 (.55)			
	158,138	19.0 (.75)						
	160,438		19.0 (.75)					
	163,338			17.8 (.70)				
	166,338				15.2 (.60)			
	173,438	20.3 (.80)						
	176,238		20.3 (.80)					
	176,738			19.0 (.75)				
	182, 238				16.5 (.65)			
	185,238	21.6 (.85)						
	188,438		21.6 (.85)					
	191,138			20.3 (.80)				
	198,138				17.8 (.70)			
	198,238	22.9 (.90)						
	201,438		22.9 (.90)					
	204,938			21.6 (.85)				
	211,338	24.1 (.95)						
	214,238		24.1 (.95)					
	215,838				19.0 (.75)			
	220,538			22.9 (.90)				
	225,438	25.4 (1.00)						
	225,738		25.4 (1.00)					
	233,738				20.3 (.80)			
	235,638			24.1 (.95)				
9 Hz	240,238	26.7 (1.05)	26.7 (1.05)					

Panel No. 2C		Primary Crack Lengths millimeters (inches)				Secondary Crack Lengths millimeters (inches)		
Cycle Rate	No. of Cycles	L/H Outside	R/H Outside	L/H Inside	R/H Inside			
9 Hz	249,338				21.6 (.85)			
	249,538			25.4 (1.00)				
	250,738	27.9 (1.10)						
	251,938		27.9 (1.10)					
	255,638			26.7 (1.05)	22.9 (.90)			
	261,088	29.2 (1.15)						
	265,538		29.2 (1.15)					
	275,338	30.5 (1.20)	30.5 (1.20)					
	280,738			27.9 (1.10)	24.1 (.95)			
	289,138	31.8 (1.25)	31.8 (1.25)					
	291,938				25.4 (1.00)			
	292,138			29.2 (1.15)				
	299,838	33.0 (1.30)	33.0 (1.30)					
	305,638			30.5 (1.20)				
	309,538				26.7 (1.05)			
	309,838	34.3 (1.35)	34.3 (1.35)					
	319,838	35.6 (1.40)	35.6 (1.40)					
	323,038				27.9 (1.10)			
	325,738			31.8 (1.25)				
	331,738		36.8 (1.45)					
	333,238	36.8 (1.45)						
	336,738				29.2 (1.15)			
	338,538			33.0 (1.30)				
	344,538		38.1 (1.50)					
	351,138	38.1 (1.50)						
	352,038			34.3 (1.35)	30.5 (1.20)			
	353,138		39.4 (1.55)					
	361,738	39.4 (1.55)	40.6 (1.60)		31.8 (1.25)			
	371,638	40.6 (1.60)	41.9 (1.65)					
	373,838			35.6 (1.40)				
	380,938			36.8 (1.45)				
9 Hz	382,138				33.0 (1.30)			

Panel No. 2C		Primary Crack Lengths millimeters (inches)				Secondary Crack Lengths millimeters (inches)		
Cycle Rate	No. of Cycles	L/H Outside	R/H Outside	L/H Inside	R/H Inside			
9 Hz	382,738	41.9 (1.65)						
	383,238		43.2 (1.70)					
	394,338				34.3 (1.35)			
	396,038	43.2 (1.70)	44.4 (1.75)					
	399,838			38.1 (1.50)				
	406,338		45.7 (1.80)					
	407,638	44.4 (1.75)		39.4 (1.55)				
	409,638				35.6 (1.40)			
	416,738		47.0 (1.85)					
	421,298	45.7 (1.80)						
	424,318			40.6 (1.60)				
9 Hz	429,218		48.3 (1.90)					
5 Hz	429,799							
	431,018				36.8 (1.45)			
	434,318	47.0 (1.85)		41.9 (1.65)				
5 Hz	438,718		49.5 (1.95)					
9 Hz	446,118			43.2 (1.70)	38.1 (1.50)			
	450,918	48.3 (1.90)	50.8 (2.00)					
	462,318			44.4 (1.75)	39.4 (1.55)			
	463,218	49.5 (1.95)	52.1 (2.05)					
	475,418	50.8 (2.00)	53.3 (2.10)					
	478,518			45.7 (1.80)	40.6 (1.60)			
	482,918		54.6 (2.15)					
	483,818	52.1 (2.05)						
	487,418			47.0 (1.85)				
	487,618				41.9 (1.65)			
	493,018		55.9 (2.20)					
	496,918	53.3 (2.10)						
	498,318			48.3 (1.90)				
	498,418				43.2 (1.70)			
	502,918		57.2 (2.25)					
9 Hz	504,218			49.5 (1.95)				

Panel No. 2C		Primary Crack Lengths millimeters (inches)				Secondary Crack Lengths millimeters (inches)		
Cycle Rate	No. of Cycles	L/H Outside	R/H Outside	L/H Inside	R/H Inside			
9 Hz	504,918				44.4 (1.75)			
	512,318	54.6 (2.15)	58.4 (2.30)					
	513,018			50.8 (2.00)				
	523,118	55.9 (2.20)	59.7 (2.35)	52.1 (2.05)	45.7 (1.80)			
	529,618			53.3 (2.10)				
	530,218		61.0 (2.40)					
	534,018				47.0 (1.85)			
	536,018	57.2 (2.25)						
	538,718		62.2 (2.45)					
	545,018	58.4 (2.30)						
	546,018			54.6 (2.15)				
	548,018				48.3 (1.90)			
	548,118		63.5 (2.50)					
	555,818				49.5 (1.95)			
	557,618	59.7 (2.35)	64.8 (2.55)					
	560,418			55.9 (2.20)				
	564,718				50.8 (2.00)			
	566,418		66.0 (2.60)					
	571,218	61.0 (2.40)						
	573,018			61.0 (2.40)				
	574,018				59.1 (2.35)			
	575,618		67.3 (2.65)					
	584,618		68.6 (2.70)	62.2 (2.45)	61.0 (2.40)			
	585,018	62.2 (2.45)						
	590,018				62.2 (2.45)			
	593,018		69.8 (2.75)					
	593,518	63.5 (2.50)						
	594,618			63.5 (2.50)	63.5 (2.50)			
	599,218		71.1 (2.80)					
	600,118			64.8 (2.55)	64.8 (2.55)			
	604,818	64.8 (2.55)						
9 Hz	605,818				66.0 (2.60)			

Panel No. 2C		Primary Crack Lengths millimeters (inches)				Secondary Crack Lengths millimeters (inches)		
Cycle Rate	No. of Cycles	L/H Outside	R/H Outside	L/H Inside	R/H Inside	#1	#2	#3
9 Hz	610,818		72.4 (2.85)					
	611,018			66.0 (2.60)				
	616,718	66.0 (2.60)	73.7 (2.90)					
	617,818				67.3 (2.65)			
	622,442			67.3 (2.65)	68.6 (2.70)			
	622,942		74.9 (2.95)					
	623,442	67.3 (2.65)						
	624,442					26.7 (1.05)		26.7 (1.05)
	628,842				69.8 (2.75)			
	629,542			68.6 (2.70)				
	630,342					27.9 (1.10)		27.9 (1.10)
	633,442		76.2 (3.00)					
	635,542					29.2 (1.15)		29.2 (1.15)
	636,342			69.8 (2.75)				
	638,242	68.6 (2.70)						
	639,142				71.1 (2.80)			
	644,942		77.5 (3.05)					
	649,142						5.1 (.20)	
	649,942			71.1 (2.80)				
	650,442					30.5 (1.20)		30.5 (1.20)
	650,742	69.8 (2.75)						
	651,342						6.4 (.25)	
	653,042						7.6 (.30)	
	654,142				72.4 (2.85)			
	659,942			72.4 (2.85)				
	660,042		78.7 (3.10)					
	662,142					31.8 (1.25)	12.7 (.50)	31.8 (1.25)
	662,642	71.1 (2.80)						
	663,642						14.0 (.55)	
	665,542						15.2 (.60)	
	666,042				73.7 (2.90)			
9 Hz	668,842						16.5 (.65)	

Panel No. 2C		Secondary Crack Lengths millimeters (inches)						
Cycle Rate	No. of Cycles	#4						
9 Hz	610,818							
	611,018							
	616,718							
	617,818							
	622,442							
	622,942							
	623,442							
	624,442							
	628,842							
	629,542							
	630,342							
	633,442							
	635,542							
	636,342							
	638,242							
	639,142							
	644,942							
	649,142	5.1 (.20)						
	649,942							
	650,442							
	650,742							
	651,342	6.4 (.25)						
	653,042	7.6 (.30)						
	654,142							
	659,942							
	660,042							
	662,142	12.7 (.50)						
	662,642							
	663,642	14.0 (.55)						
	665,542	15.2 (.60)						
	666,042							
9 Hz	668,842	16.5 (.65)						

Panel No. 2C		Primary Crack Lengths millimeters (inches)				Secondary Crack Lengths millimeters (inches)		
Cycle Rate	No. of Cycles	L/H Outside	R/H Outside	L/H Inside	R/H Inside	#1	#2	#3
9 Hz	670,042			73.7 (2.90)				
	675,142						19.0 (.75)	
	677,742						20.3 (.80)	
	679,342					33.0 (1.30)		33.0 (1.30)
	680,442	72.4 (2.85)	80.0 (3.15)					
	681,442			74.9 (2.95)				
	682,142						21.6 (.85)	
	683,042				74.9 (2.95)			
	684,842						22.9 (.90)	
	685,542	73.7 (2.90)						
	689,042						24.1 (.95)	
	696,042						26.7 (1.05)	
	696,342			76.2 (3.00)				
	696,642					34.3 (1.35)		34.3 (1.35)
	697,742				76.2 (3.00)			
	701,042				CRACK		27.9 (1.10)	
	703,642				STOPPED IN		29.2 (1.15)	
	705,542	74.9 (2.95)			BULB RADIUS			
	708,642			BULB	76.2 (3.00)		30.5 (1.20)	
	711,942	76.2 (3.00)	81.3 (3.20)	RADIUS				
	714,342			RETARDS			31.8 (1.25)	
	717,942			GROWTH			33.0 (1.30)	
	719,142					35.6 (1.40)		35.6 (1.40)
	720,342	77.5 (3.05)						
	724,342						34.3 (1.35)	
	725,942					36.8 (1.45)		36.8 (1.45)
	729,142	78.7 (3.10)						
	731,342						35.6 (1.40)	
	734,842						36.8 (1.45)	
	739,242	80.0 (3.15)						
	739,442		82.6 (3.25)					
9 Hz	739,542			76.2 (3.00)	76.2 (3.00)	38.1 (1.50)		38.1 (1.50)

Panel No. 2C		Secondary Crack Lengths millimeters (inches)						
Cycle Rate	No. of Cycles	#4						
9 Hz	670,042							
	675,142	19.0 (.75)						
	677,742	20.3 (.80)						
	679,342							
	680,442							
	681,442							
	682,142	21.6 (.85)						
	683,042							
	684,842	22.9 (.90)						
	685,542							
	689,042	24.1 (.95)						
	696,042	26.7 (1.05)						
	696,342							
	696,642							
	697,742							
	701,042	27.9 (1.10)						
	703,642	29.2 (1.15)						
	705,542							
	708,642	30.5 (1.20)						
	711,942							
	714,342	31.8 (1.25)						
	717,942	33.0 (1.30)						
	719,142							
	720,342							
	724,342	34.3 (1.35)						
	725,942							
	729,142							
	731,342	35.6 (1.40)						
	734,842	36.8 (1.45)						
	739,242							
	739,442							
9 Hz	739,542							

Panel No. 2C		Primary Crack Lengths millimeters (inches)				Secondary Crack Lengths millimeters (inches)		
Cycle Rate	No. of Cycles	L/H Outside	R/H Outside	L/H Inside	R/H Inside	#1	#2	#3
9 Hz	741,642				76.2 (3.00)		38.1 (1.50)	
	746,042			80.0 (3.15)				
	748,442			81.3 (3.20)				
	749,542			82.6 (3.25)				
	750,142					39.4 (1.55)	39.4 (1.55)	39.4 (1.55)
	751,642			83.8 (3.30)				
	752,842	81.3 (3.20)						
	753,742			85.1 (3.35)				
	755,142					40.6 (1.60)		40.6 (1.60)
	760,042			86.4 (3.40)				
	760,742						40.6 (1.60)	
	765,062						41.9 (1.65)	
	766,542			87.6 (3.45)				
	770,042			88.9 (3.50)				
	770,742						43.2 (1.70)	
	772,742	82.6 (3.25)	83.8 (3.30)					
	776,242			90.2 (3.55)				
	777,342	83.8 (3.30)						
9 Hz	779,842				76.2 (3.00)	41.9 (1.65)		41.9 (1.65)
FINAL CRACK LENGTHS		83.8 (3.30)	83.8 (3.30)	90.2 (3.55)	76.2 (3.00)	41.9 (1.65)	43.2 (1.70)	41.9 (1.70)

RESIDUAL STRENGTH = 223,290 N (50,200 lbs.)

Panel No. 2C		Secondary Crack Lengths millimeters (inches)						
Cycle Rate	No. of Cycles	#4						
9 Hz	741,642	38.1 (1.50)						
	746,042							
	748,442							
	749,542							
	750,142	39.4 (1.55)						
	751,642							
	752,842							
	753,742							
	755,142							
	760,042							
	760,742	40.6 (1.60)						
	765,062	41.9 (1.65)						
	766,542							
	770,042							
	770,742	43.2 (1.70)						
	772,742							
	776,242							
	777,342							
9 Hz	779,842							
FINAL	CRACK							
LENGTH		43.2 (1.70)						

PANEL #3C

MATERIAL: ALUMINUM-GRAPHITE

ADHESIVE: AF 126

ALUMINUM STRESS: 116 MN/m^2 (16.9 ksi)

MAXIMUM FATIGUE LOAD: 155,680N (35,000 lbf)

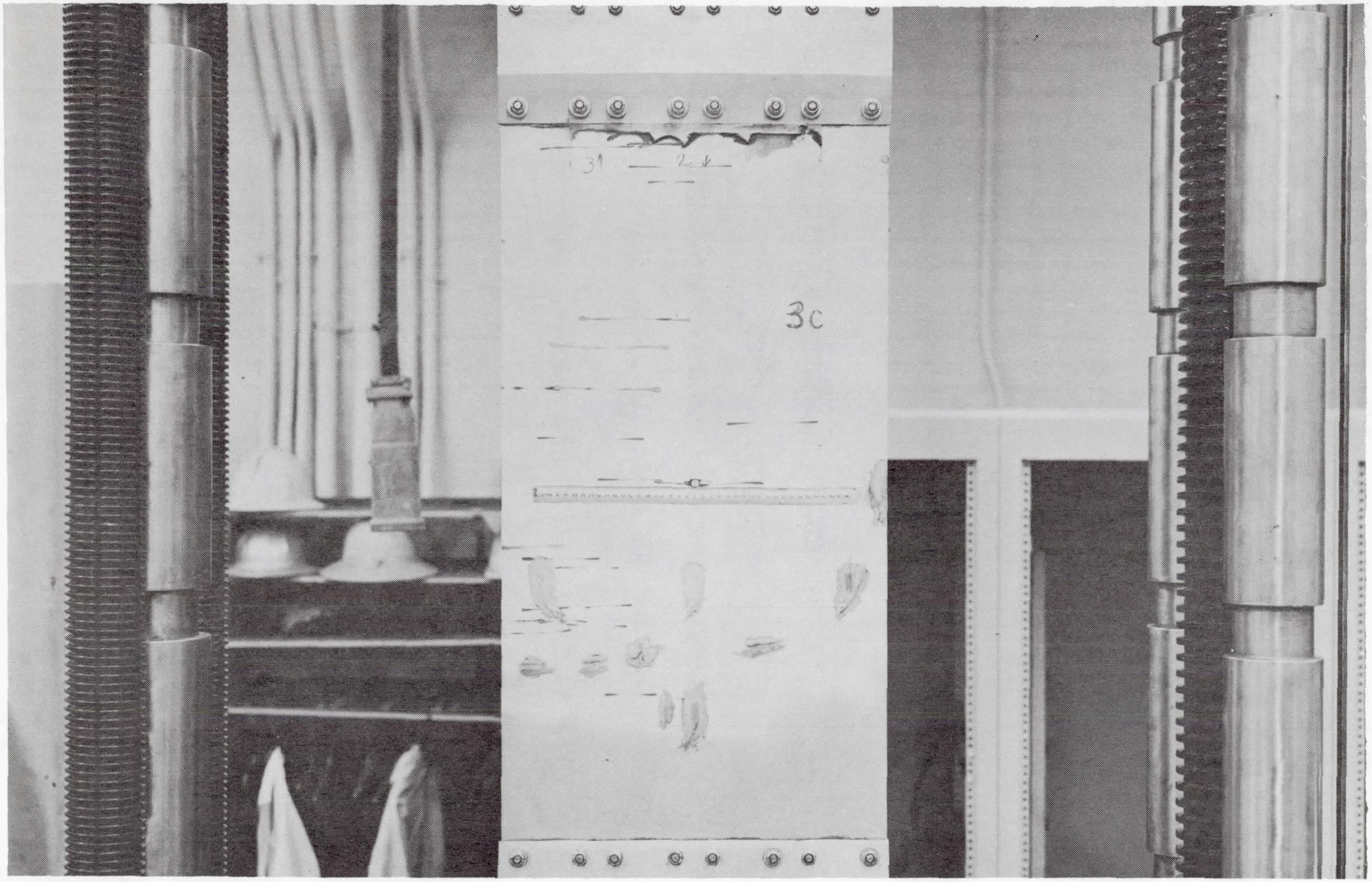

FIGURE F-9 OUTSIDE FACE SHEET AFTER CRACK GROWTH TEST - PANEL #3C

FIGURE F-10 INSIDE STIFFENER SHEET AFTER CRACK GROWTH TEST - PANEL #3C (LEFT OF CENTERLINE)

FIGURE F-11 INSIDE STIFFENER SHEET AFTER CRACK GROWTH TEST - PANEL #3C (RIGHT OF CENTERLINE)

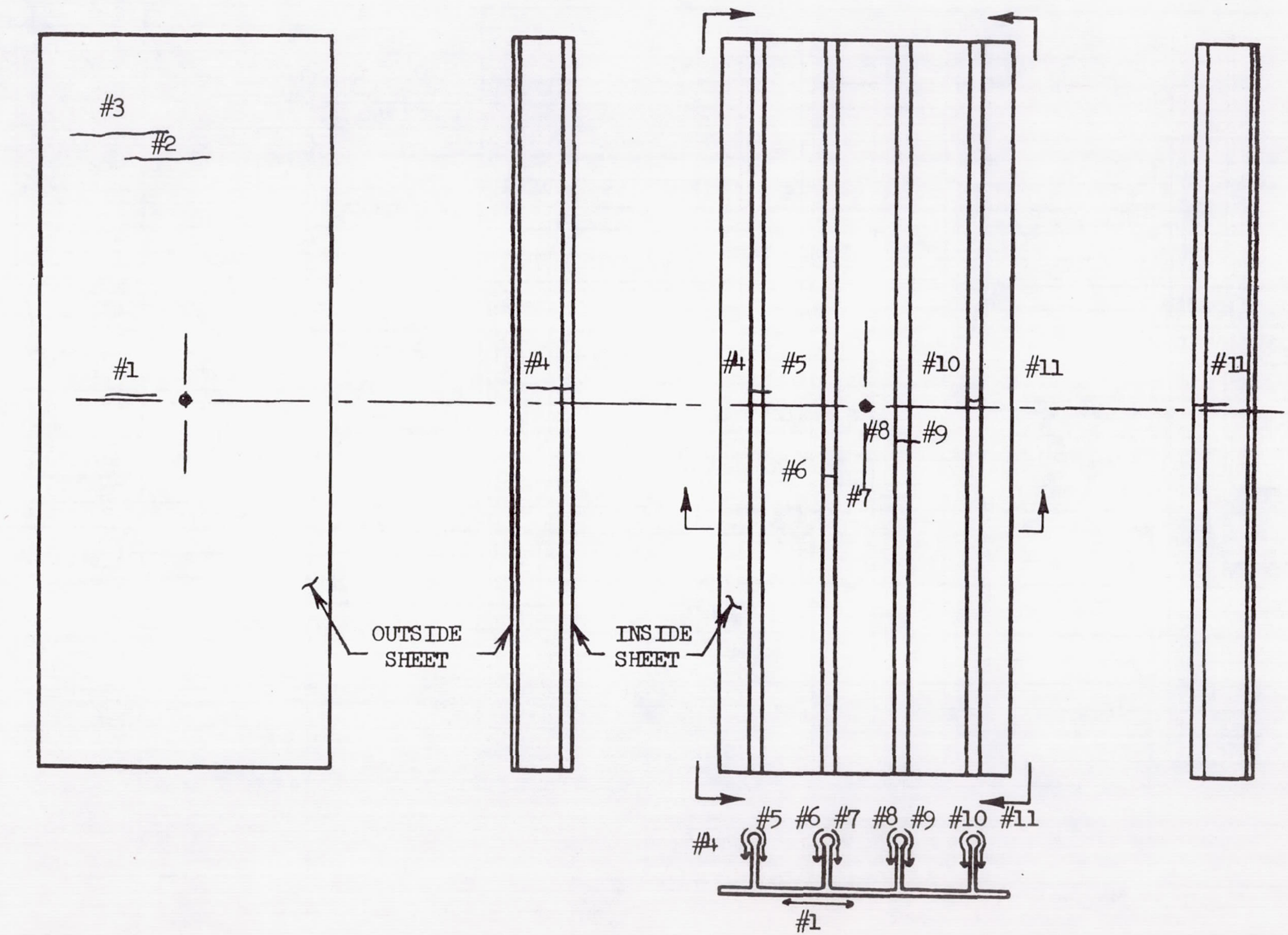

FIGURE F-12 SECONDARY CRACK LOCATIONS
ALUMINUM-GRAPHITE PANEL #3C

Panel No. 3C		Primary Crack Lengths millimeters (inches)				Secondary Crack Lengths millimeters (inches)		
Cycle Rate	No. of Cycles	L/H Outside	R/H Outside	L/H Inside	R/H Inside			
7 Hz	26,456	6.4 (.25)						
	30,824		5.1 (.20)					
	33,404	7.6 (.30)						
	37,324			Initiation	3.8 (.15)			
	40,924			3.8 (.15)				
	41,024	8.9 (.35)	6.4 (.25)					
	45,824		7.6 (.30)					
	46,224			5.1 (.20)	6.4 (.25)			
	49,224		8.9 (.35)					
	49,924			6.4 (.25)				
	53,124	10.2 (.40)						
	53,624				7.6 (.30)			
	56,724			7.6 (.30)				
	62,024				8.9 (.35)			
	68,324	11.4 (.45)	10.2 (.40)	8.9 (.35)				
	69,024				10.2 (.40)			
	79,424		11.4 (.45)					
	79,724	12.7 (.50)						
	80,524			10.2 (.40)				
	90,174	14.0 (.55)						
	90,224				11.4 (.45)			
	90,424			11.4 (.45)				
	92,024				12.7 (.50)			
	92,724		12.7 (.50)					
	95,824			12.7 (.50)				
	96,824	15.2 (.60)						
	99,024				14.0 (.55)			
	103,324		14.0 (.55)					
	104,024			14.0 (.55)				
	107,424				15.2 (.60)			
	107,624	16.5 (.65)						
7 Hz	107,924		15.2 (.60)					

Panel No. 3C		Primary Crack Lengths millimeters (inches)				Secondary Crack Lengths millimeters (inches)		
Cycle Rate	No. of Cycles	L/H Outside	R/H Outside	L/H Inside	R/H Inside	#1		
7 Hz	113,824			15.2 (.60)				
	114,024				16.5 (.65)			
	118,124	17.8 (.70)						
	120,924		16.5 (.65)					
	121,424			16.5 (.65)				
	125,424				17.8 (.70)			
	132,024	19.0 (.75)	17.8 (.70)					
	135,224			17.8 (.70)				
	135,324				19.0 (.75)			
	137,424	20.3 (.80)						
	139,324		19.0 (.75)					
	140,324			19.0 (.75)				
	144,324				20.3 (.80)			
	147,724	21.6 (.85)						
	151,824		20.3 (.80)					
	152,324			20.3 (.80)				
	157,924				21.6 (.85)			
	158,724	22.9 (.90)						
	163,424		21.6 (.85)					
	164,524			21.6 (.85)	22.9 (.90)			
	172,334			22.9 (.90)				
	176,744	24.1 (.95)						
	176,944		22.9 (.90)					
	181,444				24.1 (.95)			
	188,644			24.1 (.95)				
	193,644	25.4 (1.00)	24.1 (.95)					
	194,044				25.4 (1.00)			
	206,193	26.7 (1.05)	25.4 (1.00)			8.9 (.35)		
	209,293	27.9 (1.10)						
	210,093		26.7 (1.05)					
	214,593			34.3 (1.35)	34.3 (1.35)			
7 Hz	218,993	29.2 (1.15)						

Panel No. 3C		Primary Crack Lengths millimeters (inches)				Secondary Crack Lengths millimeters (inches)		
Cycle Rate	No. of Cycles	L/H Outside	R/H Outside	L/H Inside	R/H Inside	#1	#5	#6
7 Hz	223,493		27.9 (1.10)					
	223,993					19.0 (.75)		
	229,693					20.3 (.80)		
	235,593		29.2 (1.15)					
	241,193					21.6 (.85)		
	248,293		30.5 (1.20)					
	249,193					THIS CRACK		
	254,993	52.1 (2.05)				JOINS L/H		
	256,493				36.8 (1.45)	OUTSIDE PRI-		
	258,993		31.8 (1.25)			MARY CRACK		
	265,093	53.3 (2.10)				21.6 (.85)		
	267,193					IS ADDED		
	267,793					TO L/H		6.4 (.25)
	269,193					CRACK	10.2 (.40)	
	271,493							
	272,193						12.7 (.50)	
	273,793		33.0 (1.30)					
	273,993							7.6 (.30)
	275,093							
	278,093							
	278,593							
	278,993	54.6 (2.15)						
	279,393						14.0 (.55)	
	280,793							8.9 (.35)
	282,393						15.2 (.60)	
	282,893							
	283,593							
7 Hz	283,993							10.2 (.40)
6 Hz	285,393	55.9 (2.20)						
	285,493							
	286,093						16.5 (.65)	
6 Hz	287,593							11.4 (.45)

Panel No. 3C		Secondary Crack Lengths millimeters (inches)						
Cycle Rate	No. of Cycles	#7 Secondary	#8 Secondary	#9 Secondary				
7 Hz	223,493							
	223,993							
	229,693							
	235,593							
	241,193							
	248,293							
	249,193							
	254,993							
	256,493							
	258,993							
	265,093							
	267,193		15.2 (.60)					
	267,793							
	269,193	5.1 (.20)	16.5 (.65)	21.6 (.85)				
	271,493	6.4 (.25)						
	272,193							
	273,793							
	273,993							
	275,093	8.9 (.35)						
	278,093		17.8 (.70)					
	278,593	10.2 (.40)						
	278,993			24.1 (.95)				
	279,393							
	280,793							
	282,393							
	282,893	11.4 (.45)						
	283,593		20.3 (.80)					
7 Hz	283,993							
6 Hz	285,393							
	285,493			25.4 (1.00)				
	286,093							
6 Hz	287,593							

Panel No. 3C		Primary Crack Lengths millimeters (inches)				Secondary Crack Lengths millimeters (inches)		
Cycle Rate	No. of Cycles	L/H Outside	R/H Outside	L/H Inside	R/H Inside	#4	#5	#6
6 Hz	287,993							
↑	289,093		34.3 (1.35)					
	289,693							
	291,893							
	292,193							
	292,793						17.8 (.70)	
	293,593							12.7 (.50)
	294,193							
	295,593						19.0 (.75)	
	297,193							
	298,793						20.3 (.80)	14.0 (.55)
	301,046	57.2 (2.25)						
	301,406							
	302,906					20.3 (.80)		
	303,406		35.6 (1.40)					
	303,606							
	303,706							
	305,306						21.6 (.85)	
	307,506							
	307,806						22.9 (.90)	
	308,306							15.2 (.60)
	308,606							
	311,806						24.1 (.95)	
	312,306							
	314,306							
	315,006	58.4 (2.30)	36.8 (1.45)					
	315,506							16.5 (.65)
	315,806					21.6 (.85)		
	315,906							
	316,606						25.4 (1.00)	
↓	318,006							17.8 (.70)
6 Hz	318,406							

Panel No. 3C		Secondary Crack Lengths millimeters (inches)						
Cycle Rate	No. of Cycles	#7	#8	#9				
6 Hz	287,993			26.7 (1.05)				
	289,093							
	289,693		21.6 (.85)					
	291,893			27.9 (1.10)				
	292,193	14.0 (.55)						
	292,793							
	293,593							
	294,193		22.9 (.90)					
	295,593							
	297,193	15.2 (.60)						
	298,793							
	301,046							
	301,406		24.1 (.95)					
	302,906							
	303,406							
	303,606	16.5 (.65)						
	303,706			29.2 (1.15)				
	305,306							
	307,506	17.8 (.70)						
	307,806							
	308,306							
	308,606			30.5 (1.20)				
	311,806							
	312,306	19.0 (.75)						
	314,306		26.7 (1.05)					
	315,006							
	315,506							
	315,806							
	315,906			31.8 (1.25)				
	316,606							
	318,006							
6 Hz	318,406		27.9 (1.10)					

Panel No. 3C		Primary Crack Lengths millimeters (inches)				Secondary Crack Lengths millimeters (inches)		
Cycle Rate	No. of Cycles	L/H Outside	R/H Outside	L/H Inside	R/H Inside	#4	#5	#6
6 Hz	318,806			35.6 (1.40)				
	318,906							
	320,706				39.4 (1.55)			
	321,306							19.0 (.75)
	321,406					22.9 (.90)		
	323,806							
	325,806	59.7 (2.35)	38.1 (1.50)					
	327,006							
	328,406							
6 Hz	328,706			39.4 (1.55)				
5 Hz	328,906						27.9 (1.10)	
	329,106				40.6 (1.60)			
	329,606					25.4 (1.00)		
	333,106							
	333,706	61.0 (2.40)						
	333,806							20.3 (.80)
	334,606							
	335,006			40.6 (1.60)				
	335,306							
	336,206		39.4 (1.55)					
	336,806							21.6 (.85)
	339,806				41.9 (1.65)			
	340,106					26.7 (1.05)		
	340,406							22.9 (.90)
	340,806						29.2 (1.15)	
	343,106			41.9 (1.65)				
	344,406						30.5 (1.20)	
	345,406							24.1 (.95)
	347,706					27.9 (1.10)		
	347,906	62.2 (2.45)	40.6 (1.60)					
	348,606						31.8 (1.25)	
5 Hz	349,406							

Panel No. 3C		Secondary Crack Lengths millimeters (inches)						
Cycle Rate	No. of Cycles	#7	#8	#9				
6 Hz	318,806							
	318,906	20.3 (.80)						
	320,706							
	321,306							
	321,406							
	323,806		29.2 (1.15)					
	325,806							
	327,006			33.0 (1.30)				
	328,406	22.9 (.90)						
6 Hz	328,706							
5 Hz	328,906							
	329,106							
	329,606							
	333,106		30.5 (1.20)					
	333,706							
	333,806							
	334,606			34.3 (1.35)				
	335,006							
	335,306	24.1 (.95)						
	336,206		31.8 (1.25)					
	336,806							
	339,806							
	340,106							
	340,406							
	340,806			35.6 (1.40)				
	343,106							
	344,406							
	345,406							
	347,706							
	347,906							
	348,606							
5 Hz	349,406			36.8 (1.45)				

Panel No. 3C		Primary Crack Lengths millimeters (inches)				Secondary Crack Lengths millimeters (inches)		
Cycle Rate	No. of Cycles	L/H Outside	R/H Outside	L/H Inside	R/H Inside	#4	#5	#6
5 Hz	350,406							25.4 (1.00)
	350,606				43.2 (1.70)			
	350,906							
	352,106							
	352,806							
	353,006			43.2 (1.70)				
	354,806							
	354,906					29.2 (1.15)		
	356,906							26.7 (1.05)
	358,706							
	361,306							
	363,406	63.5 (2.50)	41.9 (1.65)					
	364,306							
	366,206							
	366,606				44.4 (1.75)			
	367,006				OVERLAPS			
	368,006				#8 SECON-			
	368,906			44.4 (1.75)	DARY CRACK			
	369,406						33.0 (1.30)	
	370,706							
	371,306							
	371,606							27.9 (1.10)
	372,106					30.5 (1.20)		
	372,406						34.3 (1.35)	
	378,806			45.7 (1.80)				
	380,206	66.0 (2.60)	43.2 (1.70)					
	381,406						35.6 (1.40)	
	382,206			47.0 (1.85)				
	382,506			OVERLAPS				
	382,806			#7 SECON-		31.8 (1.25)		
	383,006			DARY CRACK				29.2 (1.15)
5 Hz	383,206		44.4 (1.75)					

Panel No. 3C		Secondary Crack Lengths millimeters (inches)						
Cycle Rate	No. of Cycles	#7	#8	#9	#10			
5 Hz	350,406							
	350,606							
	350,906		33.0 (1.30)					
	352,106				10.2 (.40)			
	352,806	26.7 (1.05)						
	353,006							
	354,806	27.9 (1.10)						
	354,906							
	356,906							
	358,706			38.1 (1.50)				
	361,306	29.2 (1.15)						
	363,406							
	364,306	30.5 (1.20)						
	366,206		34.3 (1.35)					
	366,606		OVERLAPS R/H					
	367,006		INSIDE PRI-		11.4 (.45)			
	368,006		MARY CRACK	39.4 (1.55)				
	368,906							
	369,406							
	370,706				14.0 (.55)			
	371,306		36.8 (1.45)					
	371,606							
	372,106							
	372,406							
	378,806	31.8 (1.25)						
	380,206							
	381,406							
	382,206	OVERLAPS L/H						
	382,506	INSIDE PRI-		40.6 (1.60)				
	382,806	MARY CRACK						
	383,006							
5 Hz	383,206		38.1 (1.50)					

Panel No. 3C		Primary Crack Lengths millimeters (inches)				Secondary Crack Lengths millimeters (inches)		
Cycle Rate	No. of Cycles	L/H Outside	R/H Outside	L/H Inside	R/H Inside	#4	#5	#6
5 Hz	383,606				47.0 (1.85)			
	384,006	67.3 (2.65)						
	384,806		44.4 (1.75)					
	385,606			48.3 (1.90)				
	387,206							
	389,206	67.3 (2.65)						
	393,806				48.3 (1.90)			
	393,906			49.5 (1.95)				
	394,706							
	394,906		45.7 (1.80)					
	395,406					33.0 (1.30)		
	400,806				49.5 (1.95)			
	401,206	68.6 (2.70)						
	401,306							
	402,306						36.8 (1.45)	
	403,306							30.5 (1.20)
	403,506					34.3 (1.35)		
	404,706							
	404,906			50.8 (2.00)				
	405,806							
	410,106							
	410,606	69.8 (2.75)	47.0 (1.85)					
	414,706			52.1 (2.05)				
	416,306							
	417,206				50.8 (2.00)			
	418,906	71.1 (2.80)						
	419,206		48.3 (1.90)					
	419,506							
	419,806			53.3 (2.10)				
	421,206							33.0 (1.30)
	424,806			54.6 (2.15)				
5 Hz	424,956				52.1 (2.05)			

Panel No. 3C		Secondary Crack Lengths millimeters (inches)						
Cycle Rate	No. of Cycles	#7	#8	#9	#10			
5 Hz	383,606							
	384,006				16.5 (.65)			
	384,806							
	385,606	33.0 (1.30)						
	387,206				17.8 (.70)			
	389,206							
	393,806							
	393,906							
	394,706				19.0 (.75)			
	394,906							
	395,406							
	400,806							
	401,206							
	401,306	34.3 (1.35)						
	402,306							
	403,306							
	403,506							
	404,706			41.9 (1.65)				
	404,906							
	405,806				21.6 (.85)			
	410,106				22.9 (.90)			
	410,606							
	414,706							
	416,306				24.1 (.95)			
	417,206							
	418,906							
	419,206							
	419,506	35.6 (1.40)						
	419,806							
	421,206							
	424,806							
5 Hz	424,956							

Panel No. 3C		Primary Crack Lengths millimeters (inches)				Secondary Crack Lengths millimeters (inches)		
Cycle Rate	No. of Cycles	L/H Outside	R/H Outside	L/H Inside	R/H Inside	#4	#5	#6
5 Hz	425,606							
↑	428,006							
	428,906	72.4 (2.85)						
	431,606			55.9 (2.20)				
	432,206						38.1 (1.50)	
	432,806							
	433,106				53.3 (2.10)			
	433,606		49.5 (1.95)					
	434,206					35.6 (1.40)		
	434,806							
	435,706			57.2 (2.25)				
	439,606							
	439,706				54.6 (2.15)			
	440,406							34.3 (1.35)
	443,906			58.4 (2.30)				
	445,206	73.7 (2.90)						
	445,606							
	447,506							
	449,806				55.9 (2.20)			
	451,206							
	452,006							
	452,406						39.4 (1.55)	
	452,706		52.1 (2.05)					
	453,106	74.9 (2.95)						
	453,906							35.6 (1.40)
	454,706			59.7 (2.35)				
	458,106							
	458,306							
	460,506	76.2 (3.00)						
	462,606			61.0 (2.40)				
↓	463,606							
5 Hz	464,106				57.2 (2.25)			

Panel No. 3C		Secondary Crack Lengths millimeters (inches)						
Cycle Rate	No. of Cycles	#7	#8	#9	#10	#11		
5 Hz	425,606			43.2 (1.70)	25.4 (1.00)			
	428,006	36.8 (1.45)						
	428,906				26.7 (1.05)			
	431,606							
	432,206							
	432,806				27.9 (1.10)			
	433,106							
	433,606							
	434,206							
	434,806			44.4 (1.75)				
	435,706							
	439,606			OVERLAPS #10	29.2 (1.15)			
	439,706			SECONDARY	OVERLAPS #9			
	440,406			CRACK	SECONDARY			
	443,906				CRACK			
	445,206							
	445,606				30.5 (1.20)			
	447,506			45.7 (1.80)				
	449,806							
	451,206					14.0 (.55)		
	452,006	38.1 (1.50)						
	452,406							
	452,706							
	453,106							
	453,906							
	454,706							
	458,106					15.2 (.60)		
	458,306			47.0 (1.85)				
	460,506							
	462,606							
	463,606				34.3 (1.35)			
5 Hz	464,106							

Panel No. 3C		Primary Crack Lengths millimeters (inches)				Secondary Crack Lengths millimeters (inches)		
Cycle Rate	No. of Cycles	L/H Outside	R/H Outside	L/H Inside	R/H Inside	#4	#5	#6
5 Hz	464,306					36.8 (1.45)		
5 Hz	465,006							
5 Hz	465,606		53.3 (2.10)					
FINAL CRACK LENGTHS		76.2 (3.00)	53.3 (2.10)	61.0 (2.40)	57.2 (2.25)	36.8 (1.45)	39.4 (1.55)	35.6 (1.40)

RESIDUAL STRENGTH = 364,736 N (82,000 lbs.)

Panel No. 3C		Secondary Crack Lengths millimeters (inches)						
Cycle Rate	No. of Cycles	#7	#8	#9	#10	#11		
5 Hz	464,306							
5 Hz	465,006					17.8 (.70)		
5 Hz	465,606	39.4 (1.55)						
FINAL	CRACK							
LENGTHS		39.4 (1.55)	38.1 (1.50)	47.0 (1.85)	34.3 (1.35)	17.8 (.70)		

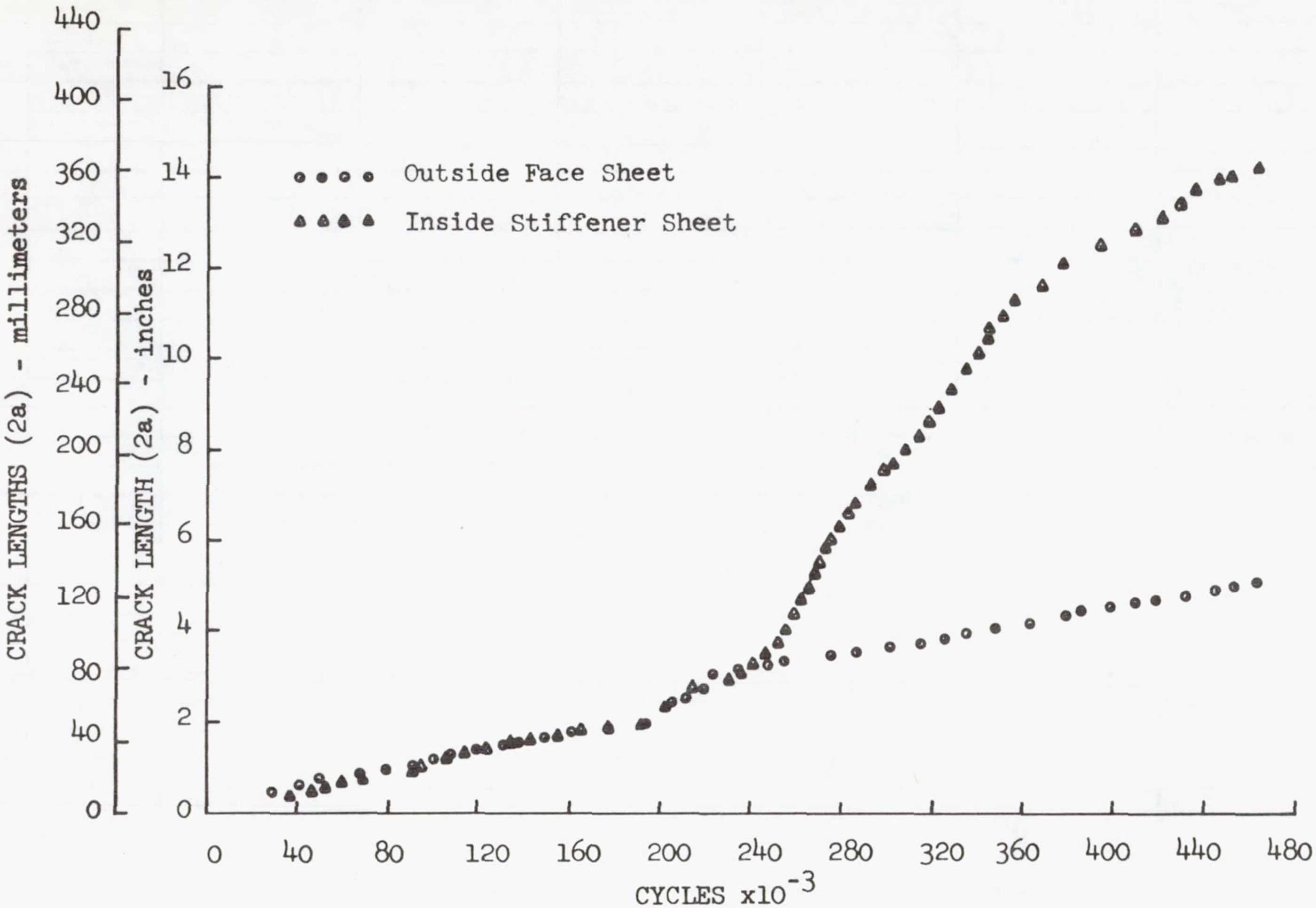

FIGURE F-13 CRACK GROWTH CURVE FOR ALUMINUM-GRAPHITE PANEL #3C
(CRACK LENGTH INCLUDES SECONDARY CRACKS)

PANEL #4C

MATERIAL: ALUMINUM-GRAPHITE

ADHESIVE: AF 126

ALUMINUM STRESS: 116 MN/m^2 (16.9 ksi)

MAXIMUM FATIGUE LOAD: 137,890N (31,000 lbf)

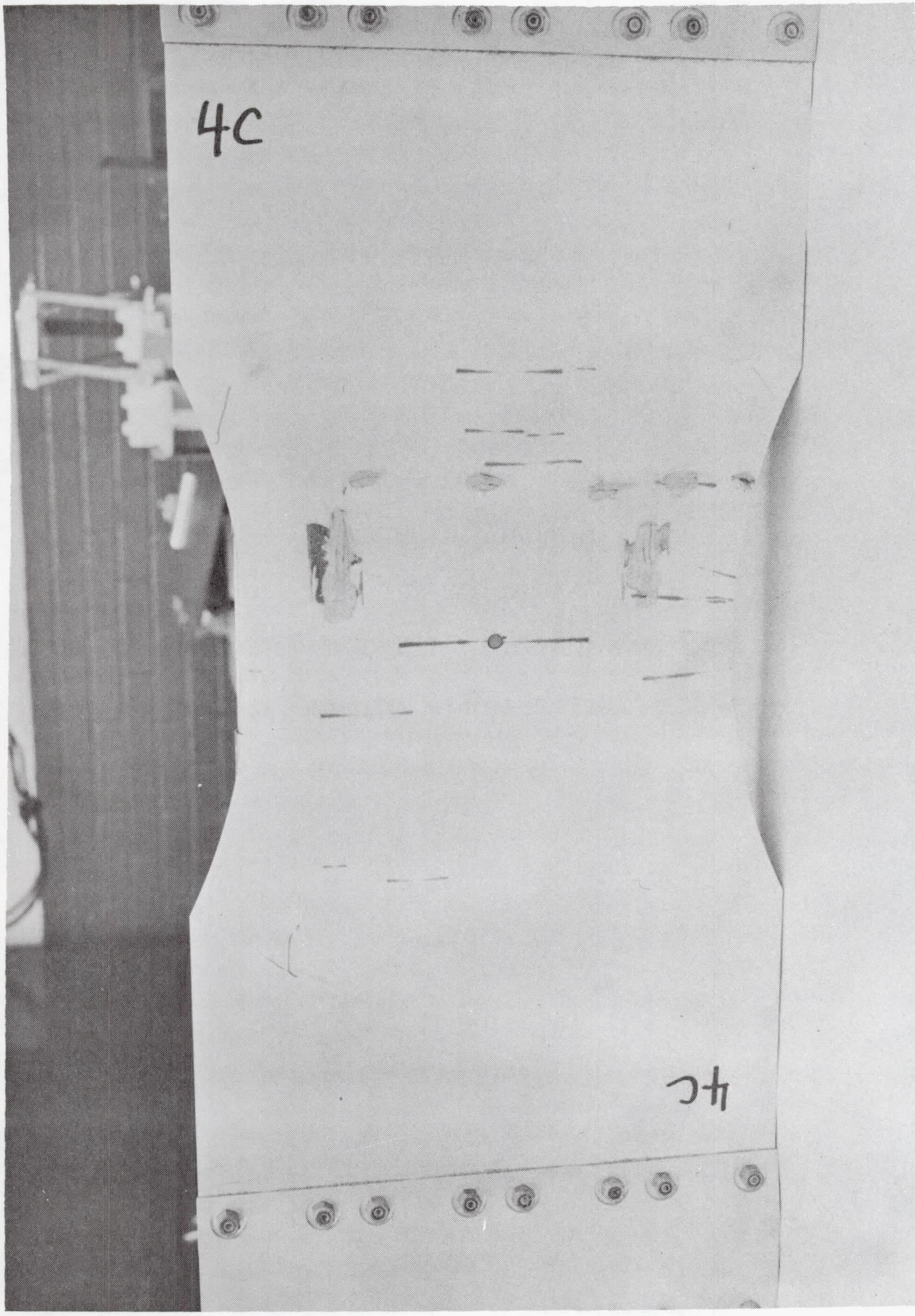

FIGURE F-14 OUTSIDE FACE SHEET AFTER CRACK GROWTH TEST - PANEL #4C

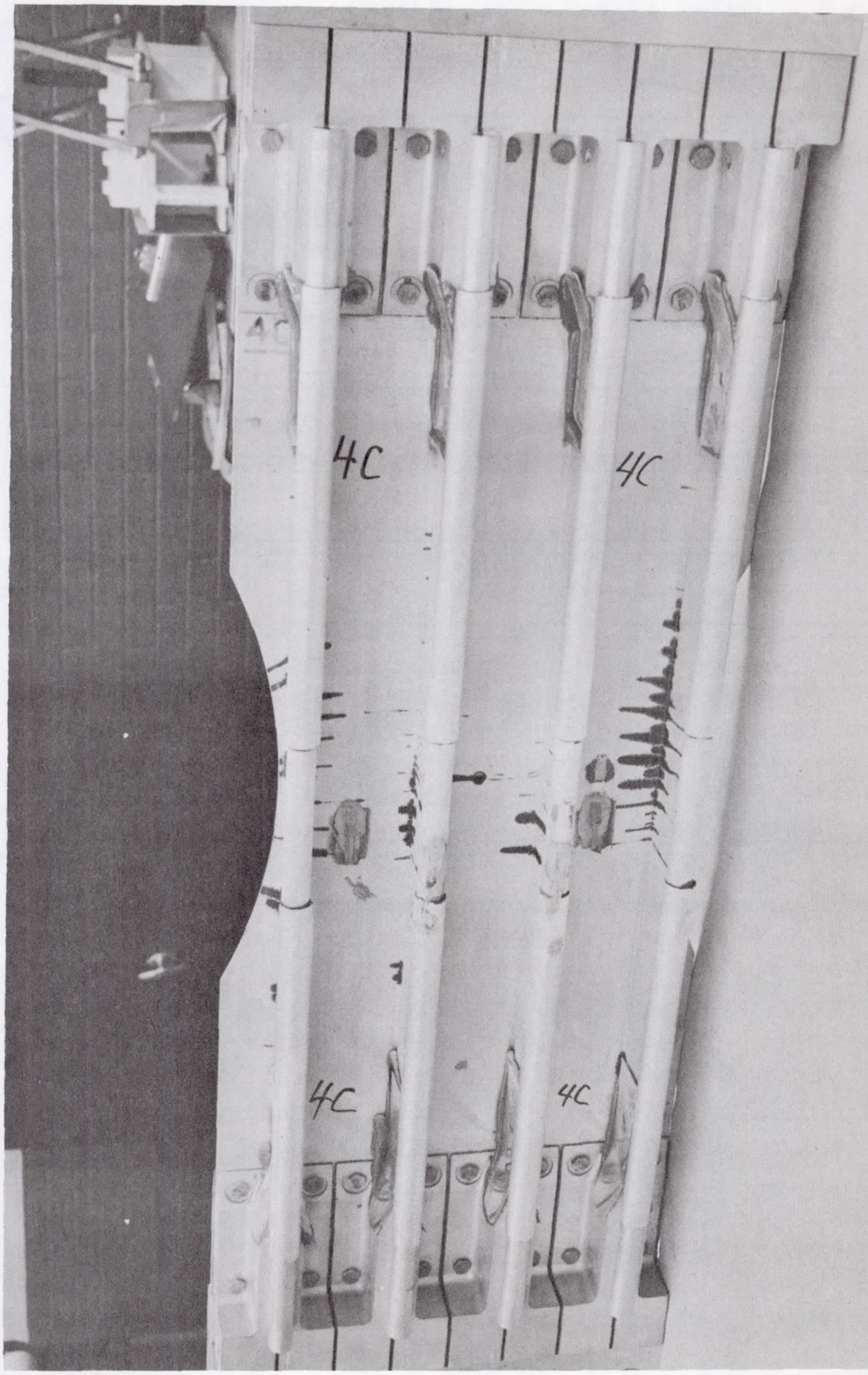

FIGURE F-15 INSIDE STIFFENER SHEET AFTER CRACK GROWTH TEST - PANEL #4C

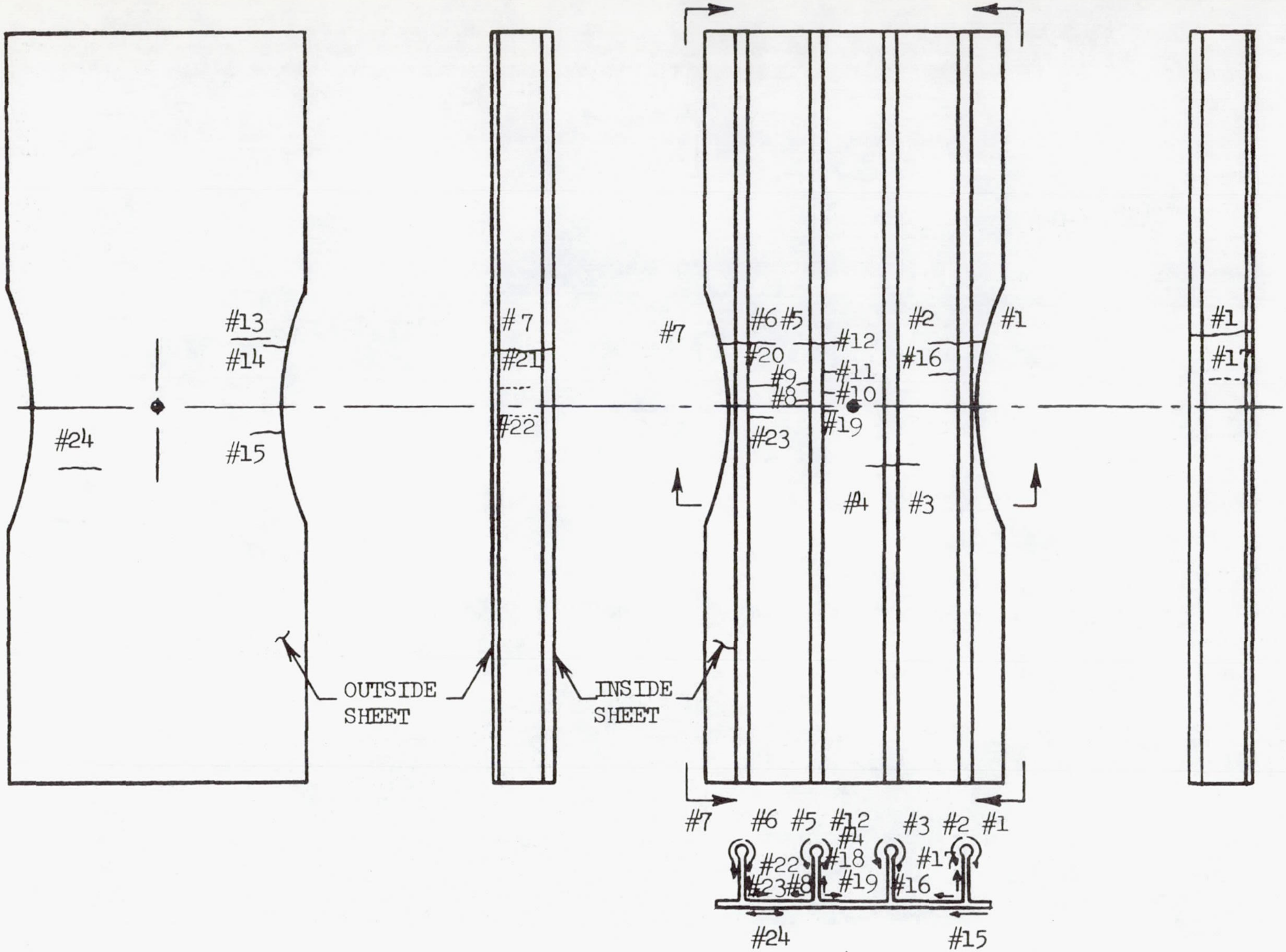

FIGURE F-16 SECONDARY CRACK LOCATIONS
ALUMINUM-GRAPHITE PANEL #4C

Panel No. 4C		Primary Crack Lengths millimeters (inches)				Secondary Crack Lengths millimeters (inches)		
Cycle Rate	No. of Cycles	L/H Outside	R/H Outside	L/H Inside	R/H Inside	#1	#2	#3
5 Hz	3,879				3.8 (.15)			
	16,179				5.1 (.20)			
	19,079	3.8 (.15)						
	22,179	5.1 (.20)	3.8 (.15)		6.4 (.25)			
	25,279			3.8 (.15)				
	25,879		5.1 (.20)					
	26,279				7.6 (.30)			
5 Hz	28,279	6.4 (.25)						
6 Hz	30,279			5.1 (.20)				
	32,479		6.4 (.25)					
	33,579				8.9 (.35)			
	41,979	7.6 (.30)						
	44,779	8.9 (.35)	7.6 (.30)					
	45,779			6.4 (.25)	10.2 (.40)			
	47,679		8.9 (.35)					7.6 (.30)
6 Hz	48,379						22.9 (.90)	
3 Hz	48,519						25.4 (1.00)	
	48,779							
	48,879				11.4 (.45)			
	49,079							10.2 (.40)
	49,279						27.9 (1.10)	
	49,929					36.8 (1.45)		
	50,079							11.4 (.45)
	50,279							
	50,479						30.5 (1.20)	
	50,679					38.1 (1.50)		
	50,779	10.2 (.40)						
	51,379						31.8 (1.25)	
	51,679							12.7 (.50)
	52,279							14.0 (.55)
	54,179		10.2 (.40)				34.3 (1.35)	16.5 (.65)
3 Hz	54,279					39.4 (1.55)		

Panel No. 4C		Primary Crack Lengths millimeters (inches)				Secondary Crack Lengths millimeters (inches)		
Cycle Rate	No. of Cycles	L/H Outside	R/H Outside	L/H Inside	R/H Inside	#1	#2	#3
3 Hz	54,379			7.6 (.30)				
	54,779							
	55,179							
	56,179							20.3 (.80)
	56,479							
	56,879						35.6 (1.40)	
	57,079				12.7 (.50)			
	57,379					40.6 (1.60)		
	57,479							22.9 (.90)
	57,779						36.8 (1.45)	
	57,879							
	58,179							24.1 (.95)
	59,079							25.4 (1.00)
	59,579							
3 Hz	59,679			8.9 (.35)				26.7 (1.05)
4 Hz	63,203					41.9 (1.65)		
	63,703							
	64,903						38.1 (1.50)	
4 Hz	65,103	11.4 (.45)	11.4 (.45)					
5 Hz	65,803							
	66,103							
	66,503							
	67,703					43.2 (1.70)		
	70,603		12.7 (.50)					
	73,303							27.9 (1.10)
	73,603					44.4 (1.75)		
	73,703						39.4 (1.55)	
	73,903			10.2 (.40)	15.2 (.60)			
	74,103							
	74,903							
	76,003			11.4 (.45)				
5 Hz	76,103	12.7 (.50)						

Panel No. 4C		Secondary Crack Lengths millimeters (inches)						
Cycle Rate	No. of Cycles	#4	#5					
3 Hz	54,379							
	54,779	34.3 (1.35)						
	55,179		11.4 (.45)					
	56,179							
	56,479		12.7 (.50)					
	56,879							
	57,079							
	57,379							
	57,479							
	57,779							
	57,879	35.6 (1.40)						
	58,179							
	59,079							
	59,579		15.2 (.60)					
3 Hz	59,679							
4 Hz	63,203							
	63,703							
	64,903							
4 Hz	65,103							
5 Hz	65,803							
	66,103	36.8 (1.45)						
	66,503		17.8 (.70)					
	67,703							
	70,603							
	73,303							
	73,603							
	73,703							
	73,903							
	74,103	38.1 (1.50)						
	74,903		20.3 (.80)					
	76,003							
5 Hz	76,103							

Panel No. 4C		Primary Crack Lengths millimeters (inches)				Secondary Crack Lengths millimeters (inches)		
Cycle Rate	No. of Cycles	L/H Outside	R/H Outside	L/H Inside	R/H Inside	#1	#2	#3
5 Hz	76,603							29.2 (1.15)
	77,003					45.7 (1.80)		
	78,103						40.6 (1.60)	
	80,003							
	80,103							
	80,503		14.0 (.55)					
	81,203							
	82,603				16.5 (.65)			
	82,703						41.9 (1.65)	
	83,003							30.5 (1.20)
	83,403					48.3 (1.90)		
	85,103	14.0 (.55)						
	87,203				17.8 (.70)			
	87,703							
	88,203		15.2 (.60)					
	88,303						43.2 (1.70)	
	88,703					49.5 (1.95)		
	89,003					Edge of Panel		31.8 (1.25)
	89,603							
	89,703			12.7 (.50)				
	90,703							
	90,803							
	91,703							
	92,603	15.2 (.60)						
	94,403			14.0 (.55)				35.6 (1.40)
	97,703							
	98,603				19.0 (.75)			
	98,903						44.4 (1.75)	
	99,603							
	99,803		16.5 (.65)					
	100,303							
5 Hz	101,303					49.5 (1.95)		38.1 (1.50)

Panel No. 4C		Secondary Crack Lengths millimeters (inches)						
Cycle Rate	No. of Cycles	#4	#5	#6	#7			
5 Hz	76,603							
↑	77,003							
	78,103							
	80,003			21.6 (.85)				
	80,103				39.4 (1.55)			
	80,503							
	81,203			29.2 (1.15)				
	82,603							
	82,703							
	83,003							
	83,403							
	85,103							
	87,203							
	87,703				41.9 (1.65)			
	88,203							
	88,303							
	88,703							
	89,003							
	89,603			36.8 (1.45)				
	89,703							
	90,703				43.2 (1.70)			
	90,803	40.6 (1.60)						
	91,703			38.1 (1.50)				
	92,603							
	94,403			39.4 (1.55)				
	97,703				44.4 (1.75)			
	98,603							
	98,903							
	99,603	41.9 (1.65)						
	99,803							
↓	100,303			40.6 (1.60)				
5 Hz	101,303							

Panel No. 4C		Primary Crack Lengths millimeters (inches)				Secondary Crack Lengths millimeters (inches)		
Cycle Rate	No. of Cycles	L/H Outside	R/H Outside	L/H Inside	R/H Inside	#1	#2	#3
5 Hz	103,003	16.5 (.65)				49.5 (1.95)		
6 Hz	104,903							
	105,703			15.2 (.60)	20.3 (.80)			
	109,203		17.8 (.70)					
	111,703						45.7 (1.80)	
	112,303							
	112,603			16.5 (.65)				
	113,403	17.8 (.70)						
	113,703							
	113,803				21.6 (.85)			
	117,003		19.0 (.75)					
	117,603							
	118,003							
	118,603							
	119,103						47.0 (1.85)	
	123,603			17.8 (.70)	22.9 (.90)			
	124,003	19.0 (.75)						
	124,703							39.4 (1.55)
	129,003							
	129,203		20.3 (.80)					
	129,703							41.5 (1.65)
	131,003							
	131,803						48.3 (1.90)	
	132,203							
	133,103	20.3 (.80)						
	134,703			19.0 (.75)	24.1 (.95)			
	137,403							
	139,503		21.6 (.85)					
	142,003				25.4 (1.00)			
	142,203							
	142,603			20.3 (.80)				
6 Hz	143,303					49.5 (1.95)	49.5 (1.95)	

Panel No. 4C		Secondary Crack Lengths millimeters (inches)						
Cycle Rate	No. of Cycles	#4	#5	#6	#7			
5 Hz	103,003							
6 Hz	104,903							
	105,703							
	109,203							
	111,703							
	112,303			41.5 (1.65)				
	112,603							
	113,403							
	113,703				47.0 (1.85)			
	113,803							
	117,003							
	117,603			43.2 (1.70)				
	118,003				48.3 (1.90)			
	118,603	44.4 (1.75)						
	119,103							
	123,603							
	124,003							
	124,703							
	129,003			44.4 (1.75)				
	129,203							
	129,703							
	131,003				50.8 (2.00)			
	131,803				EDGE OF			
	132,203	45.7 (1.80)			PANEL			
	133,103							
	134,703							
	137,403			45.7 (1.80)				
	139,503							
	142,003							
	142,203	47.0 (1.85)						
	142,603							
6 Hz	143,303				50.8 (2.00)			

Panel No. 4C		Primary Crack Lengths millimeters (inches)				Secondary Crack Lengths millimeters (inches)		
Cycle Rate	No. of Cycles	L/H Outside	R/H Outside	L/H Inside	R/H Inside	#1	#2	#3
6 Hz	144,203					49.5 (1.95)		
	147,603	21.6 (.85)						
	147,703							44.4 (1.75)
	148,803						50.8 (2.00)	
	149,703							
	149,722		22.9 (.90)					
	152,222	22.9 (.90)						
	154,722							
	157,522							
	157,682		24.1 (.95)					
	158,722			22.9 (.90)				
	160,022							
	160,722							
	160,822							47.0 (1.85)
	161,222							
	161,722						52.1 (2.05)	
	161,822				27.9 (1.10)			
	165,122	24.1 (.95)						
	166,122		25.4 (1.00)					
	166,722							
	167,322							
	167,722							48.3 (1.90)
	168,022							
	168,722							
	168,822	25.4 (1.00)						
	169,822				29.2 (1.15)			
	170,022			24.1 (.95)	OVERLAPS #4			
	170,422				SECONDARY		54.6 (2.15)	
	172,822		26.7 (1.05)		CRACK			
	173,522	26.7 (1.05)						
	175,622			25.4 (1.00)				
6 Hz	176,122					49.5 (1.95)		

Panel No. 4C		Secondary Crack Lengths millimeters (inches)						
Cycle Rate	No. of Cycles	#4	#5	#6	#7	#12	#13	#14
6 Hz	144,203			47.0 (1.85)	50.8 (2.00)			
	147,603							
	147,703							
	148,803							
	149,703			48.3 (1.90)				
	149,722		41.9 (1.65)					
	152,222							
	154,722					43.2 (1.70)		
	157,522			50.8 (2.00)				
	157,682							
	158,722							
	160,022					44.4 (1.75)		
	160,722						12.7 (.50)	7.6 (.30)
	160,822							
	161,222		43.2 (1.70)					
	161,722							
	161,822							
	165,122							
	166,122							
	166,722						15.2 (.60)	10.2 (.40)
	167,322			52.1 (2.05)				
	167,722							
	168,022	49.5 (1.95)						
	168,722		44.4 (1.75)					
	168,822							
	169,822	OVERLAPS R/H						
	170,022	INSIDE PRI-						
	170,422	MARY CRACK		53.3 (2.10)				
	172,822							
	173,522							
	175,622							
6 Hz	176,122				50.8 (2.00)		17.8 (.70)	12.7 (.50)

Panel No. 4C		Primary Crack Lengths millimeters (inches)				Secondary Crack Lengths millimeters (inches)		
Cycle Rate	No. of Cycles	L/H Outside	R/H Outside	L/H Inside	R/H Inside	#1	#2	#3
6 Hz	178,422					49.5 (1.95)		
	179,922		27.9 (1.10)					
	180,222							
	180,322				30.5 (1.20)			
	182,022							
	182,422						55.9 (2.20)	50.8 (2.00)
	185,122			26.7 (1.05)				
	185,622							
	186,822	27.9 (1.10)						
	188,122							
	188,522		29.2 (1.15)					
	188,822				31.8 (1.25)			
	190,022							
	193,722							
	193,822							52.1 (2.05)
	194,622	29.2 (1.15)						
	195,322						57.2 (2.25)	
	196,522							
	198,122							
	199,622				33.0 (1.30)			
	200,522			29.2 (1.15)				
	202,122	30.5 (1.20)	30.5 (1.20)					
	206,022							53.3 (2.10)
	207,322							
	207,922							
	208,222						64.8 (2.55)	
	209,222							
	210,522				34.3 (1.35)			
	210,922			30.5 (1.20)				
	212,122			OVERLAPS #12				
	213,722	31.8 (1.25)	31.8 (1.25)	SECONDARY				
6 Hz	215,322			CRACK		49.5 (1.95)	66.0 (2.60)	55.9 (2.20)

Panel No. 4C		Secondary Crack Lengths millimeters (inches)						
Cycle Rate	No. of Cycles	#4	#5	#6	#7	#12	#13	#14
6 Hz	178,422			54.6 (2.15)	50.8 (2.00)			
	179,922							
	180,222	50.8 (2.00)						
	180,322							
	182,022					45.7 (1.80)		
	182,422		45.7 (1.80)	55.9 (2.20)				
	185,122							
	185,622					47.0 (1.85)		
	186,822							
	188,122		47.0 (1.85)					
	188,522							
	188,822							
	190,022						20.3 (.80)	OVERLAPS
	193,722	52.1 (2.05)				48.3 (1.90)		#13
	193,822							SECONDARY
	194,622							CRACK
	195,322							(DATA
	196,522		48.3 (1.90)					RECORDING
	198,122						22.9 (.90)	DISCONTINUED)
	199,622							
	200,522							
	202,122							
	206,022							
	207,322			59.7 (2.35)				
	207,922	54.6 (2.15)						
	208,222							
	209,222		49.5 (1.95)					
	210,522							
	210,922					← OVERLAPS L/H		
	212,122			61.0 (2.40)		INSIDE PRI-		
	213,722					MARY CRACK		
6 Hz	215,322				50.8 (2.00)			12.7 (.50)

Panel No. 4C		Primary Crack Lengths millimeters (inches)				Secondary Crack Lengths millimeters (inches)		
Cycle Rate	No. of Cycles	L/H Outside	R/H Outside	L/H Inside	R/H Inside	#1	#2	#3
6 Hz	218,122					49.5 (1.95)		
	218,191	33.0 (1.30)	33.0 (1.30)				67.3 (2.65)	
	221,791							
	225,951	34.3 (1.35)	34.3 (1.35)					
	227,691				35.6 (1.40)			
	227,891							
	228,091			33.0 (1.30)				
	229,391							58.4 (2.30)
	230,891						69.8 (2.75)	
	231,591							
	231,791							
	233,191							
	233,791		35.6 (1.40)	34.3 (1.35)				
	234,191							
	235,791				36.8 (1.45)			
	241,191						71.1 (2.80)	
	241,291							
	241,891							
	242,191	35.6 (1.40)						
	243,291							
	243,791							59.7 (2.35)
	244,891							
	245,591	36.8 (1.45)	36.8 (1.45)					
	246,391							
	252,091	38.1 (1.50)	38.1 (1.50)					
	252,691							
	253,391				38.1 (1.50)		73.7 (2.90)	62.2 (2.45)
	258,191	39.4 (1.55)	39.4 (1.55)					
	263,191							63.5 (2.50)
	263,991							
	264,391	40.6 (1.60)						
6 Hz	264,491					49.5 (1.95)		

Panel No. 4C		Secondary Crack Lengths millimeters (inches)						
Cycle Rate	No. of Cycles	#4	#5	#6	#7	#12	#13	#14
6 Hz	218,122				50.8 (2.00)			12.7 (.50)
	218,191						25.4 (1.00)	
	221,791		50.8 (2.00)					
	225,951							
	227,691							
	227,891	55.9 (2.20)						
	228,091							
	229,391							
	230,891							
	231,591						27.9 (1.10)	
	231,791			64.8 (2.55)				
	233,191	57.2 (2.25)						
	233,791							
	234,191		52.1 (2.05)					
	235,791							
	241,191							
	241,291	58.4 (2.30)						
	241,891		53.3 (2.10)					
	242,191							
	243,291					52.1 (2.05)		
	243,791							
	244,891			66.0 (2.60)				
	245,591							
	246,391						30.5 (1.20)	
	252,091							
	252,691		54.6 (2.15)					
	253,391			67.3 (2.65)				
	258,191							
	263,191							
	263,991						33.0 (1.30)	
	264,391							
6 Hz	264,491				50.8 (2.00)			12.7 (.50)

Panel No. 4C		Secondary Crack Lengths millimeters (inches)						
Cycle Rate	No. of Cycles	#24						
6 Hz	218,122							
	218,191							
	221,791							
	225,951							
	227,691							
	227,891							
	228,091							
	229,391							
	230,891							
	231,591							
	231,791							
	233,191							
	233,791							
	234,191							
	235,791							
	241,191							
	241,291							
	241,891							
	242,191							
	243,291							
	243,791							
	244,891							
	245,591							
	246,391							
	252,091							
	252,691							
	253,391							
	258,191	29.2 (1.15)						
	263,191							
	263,991							
	264,391							
6 Hz	264,491	31.8 (1.25)						

Panel No. 4C		Primary Crack Lengths millimeters (inches)				Secondary Crack Lengths millimeters (inches)		
Cycle Rate	No. of Cycles	L/H Outside	R/H Outside	L/H Inside	R/H Inside	#1	#2	#3
6 Hz	264,591		40.6 (1.60)			49.5 (1.95)		
	266,191							
	266,791							
	267,591							
	269,091							
	269,191				40.6 (1.60)			
	269,391							
	273,791			35.6 (1.40)				
	275,391	41.5 (1.65)	41.5 (1.65)					
	275,991							
	276,491				41.5 (1.65)			
	280,691							
	281,391							
	281,591				43.2 (1.70)			
	282,691	43.2 (1.70)	43.2 (1.70)					
	285,891				44.4 (1.75)			
	285,991							
	289,191							
	290,091				45.7 (1.80)			
	291,791	44.4 (1.75)	44.4 (1.75)					
	294,791				47.0 (1.85)			
	295,791							
	297,191							
	298,091							73.7 (2.90)
	298,791	45.7 (1.80)	45.7 (1.80)					
	298,991							
	301,991				48.3 (1.90)			
	302,191						83.8 (3.30)	
	302,491	47.0 (1.85)						
	302,591							
	303,291							
6 Hz	304,091					49.5 (1.95)		74.9 (2.95)

Panel No. 4C		Secondary Crack Lengths millimeters (inches)						
Cycle Rate	No. of Cycles	#4	#5	#6	#7	#12	#13	#14
6 Hz	264,591				50.8 (2.00)			12.7 (.50)
	266,191					54.6 (2.15)		
	266,791			68.6 (2.70)				
	267,591			69.8 (2.75)				
	269,091		57.2 (2.25)					
	269,191							
	269,391	63.5 (2.50)						
	273,791							
	275,391							
	275,991					55.9 (2.20)		
	276,491							
	280,691		58.4 (2.30)					
	281,391	64.8 (2.55)						
	281,591							
	282,691							
	285,891							
	285,991	66.0 (2.60)						
	289,191		59.7 (2.35)					
	290,091							
	291,791							
	294,791							
	295,791		61.0 (2.40)					
	297,191					59.7 (2.35)		
	298,091							
	298,791							
	298,991			76.2 (3.00)				
	301,991							
	302,191							
	302,491							
	302,591	68.6 (2.70)						
	303,291							
6 Hz	304,091				50.8 (2.00)			12.7 (.50)

Panel No. 4C		Secondary Crack Lengths millimeters (inches)						
Cycle Rate	No. of Cycles	#24						
6 Hz	264,591							
↑	266,191							
	266,791							
	267,591							
	269,091							
	269,191							
	269,391							
	273,791							
	275,391							
	275,991							
	276,491							
	280,691							
	281,391							
	281,591							
	282,691							
	285,891							
	285,991							
	289,191							
	290,091							
	291,791							
	294,791							
	295,791							
	297,191							
	298,091							
	298,791							
	298,991							
	301,991							
	302,191							
	302,491							
	302,591							
↓	303,291	44.4 (1.75)						
6 Hz	304,091							

Panel No. 4C		Primary Crack Lengths millimeters (inches)				Secondary Crack Lengths millimeters (inches)		
Cycle Rate	No. of Cycles	L/H Outside	R/H Outside	L/H Inside	R/H Inside	#1	#2	#3
6 Hz	304,134		47.0 (1.85)			49.5 (1.95)		
FINAL CRACK LENGTHS		47.0 (1.85)	47.0 (1.85)	35.6 (1.40)	48.3 (1.90)	49.5 (1.95)	83.8 (3.30)	74.9 (2.95)
		RESIDUAL STRENGTH = 263,770 N (59,300 lbs.)						

Panel No. 4C		Secondary Crack Lengths millimeters (inches)						
Cycle Rate	No. of Cycles	#4	#5	#6	#7	#12	#13	#14
6 Hz	304,134		62.2 (2.45)	77.5 (3.05)	50.8 (2.00)		40.6 (1.60)	12.7 (.50)
FINAL CRACK LENGTHS		68.6 (2.70)	62.2 (2.45)	77.5 (3.05)	50.8 (2.00)	59.7 (2.35)	40.6 (1.60)	12.7 (.50)

Panel No. 4C		Secondary Crack Lengths millimeters (inches)						
Cycle Rate	No. of Cycles	#24						
6 Hz	304,134							
FINAL CRACK LENGTH		44.4 (1.75)						

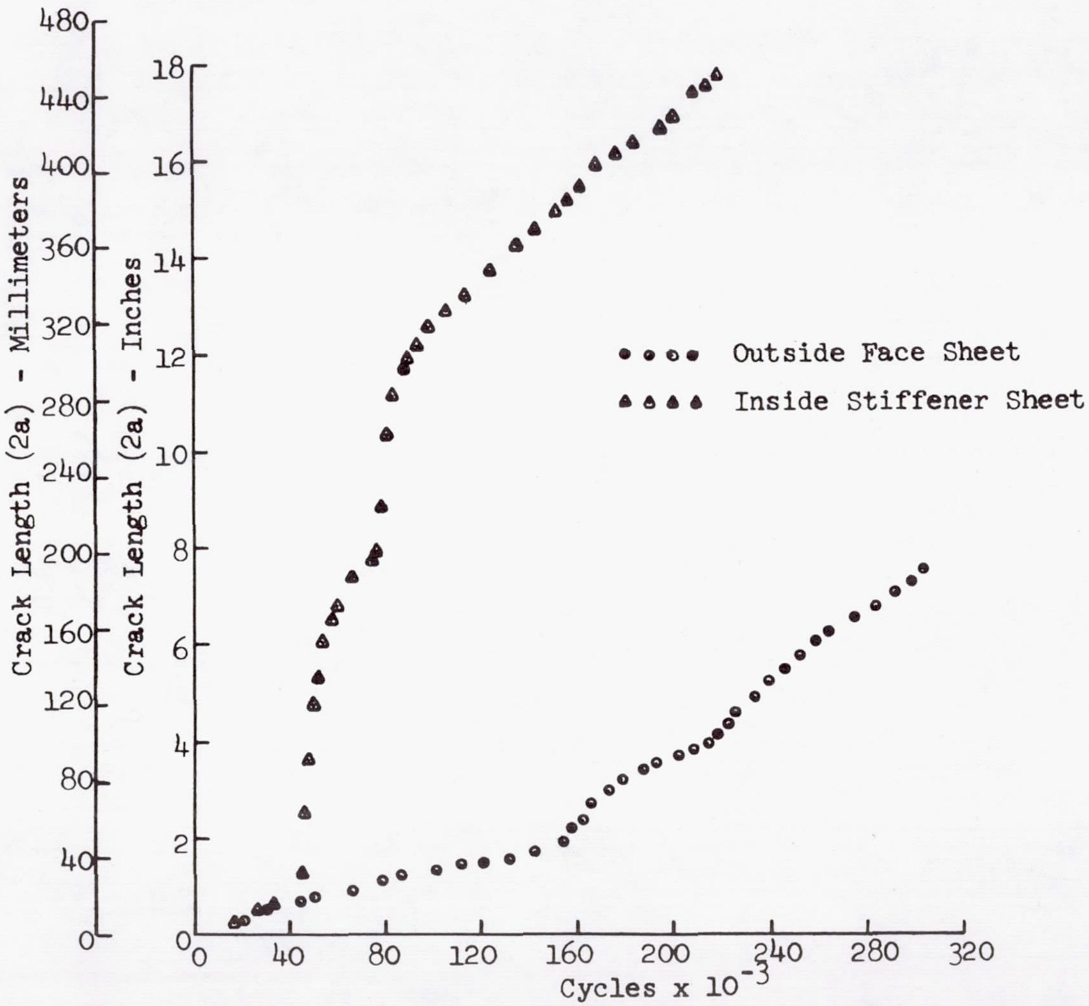

FIGURE F-17 CRACK GROWTH CURVE FOR ALUMINUM-GRAPHITE PANEL #4C (CRACK LENGTH INCLUDES SECONDARY CRACK)

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PANEL #5C

MATERIAL: ALUMINUM-GRAPHITE

ADHESIVE: AF 126

ALUMINUM STRESS: 172 MN/m^2 (25 ksi)

MAXIMUM FATIGUE LOAD: 200,160N (45,000 lbf)

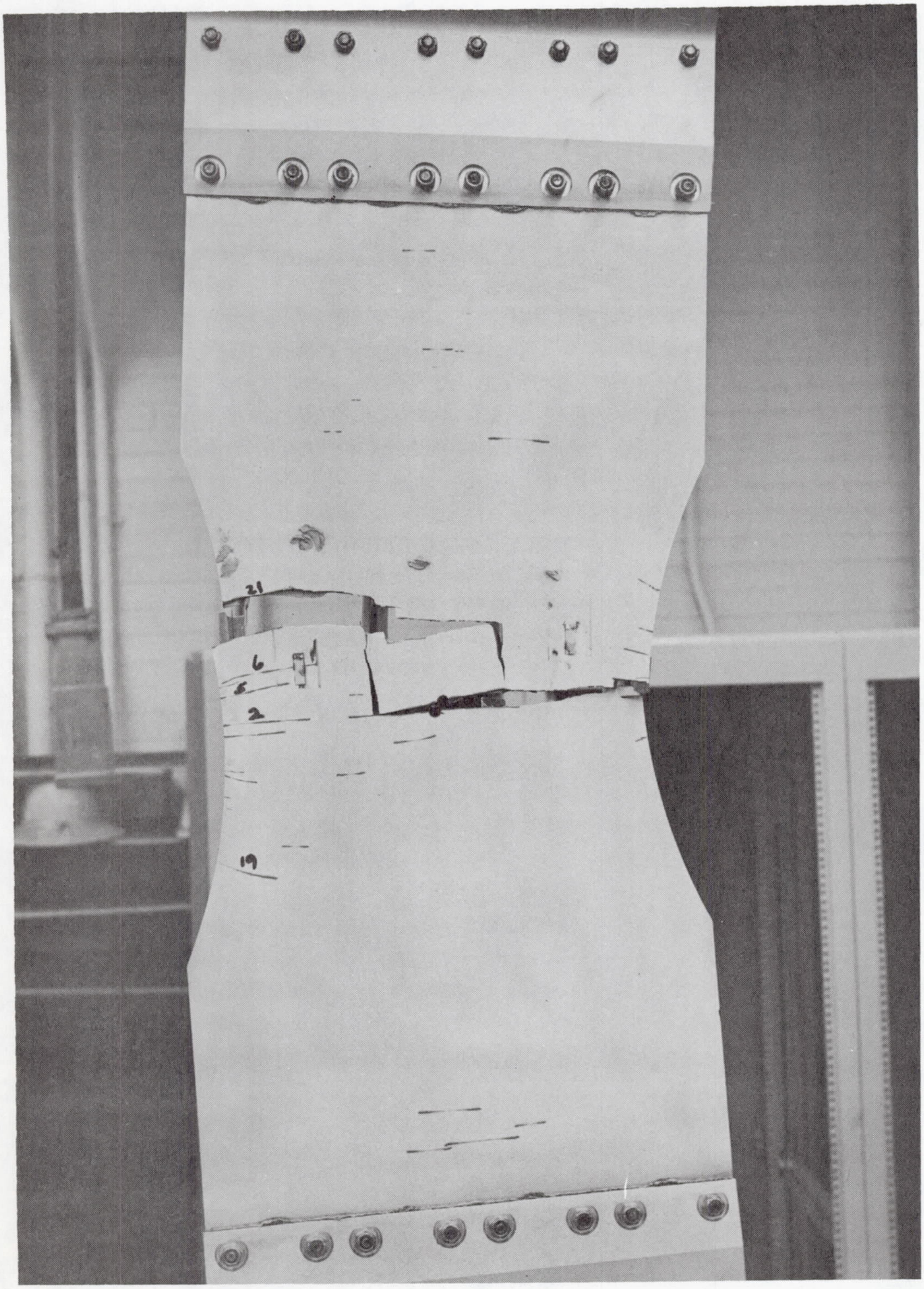

FIGURE F-18 OUTSIDE FACE SHEET AFTER RESIDUAL STRENGTH TEST - PANEL #5C

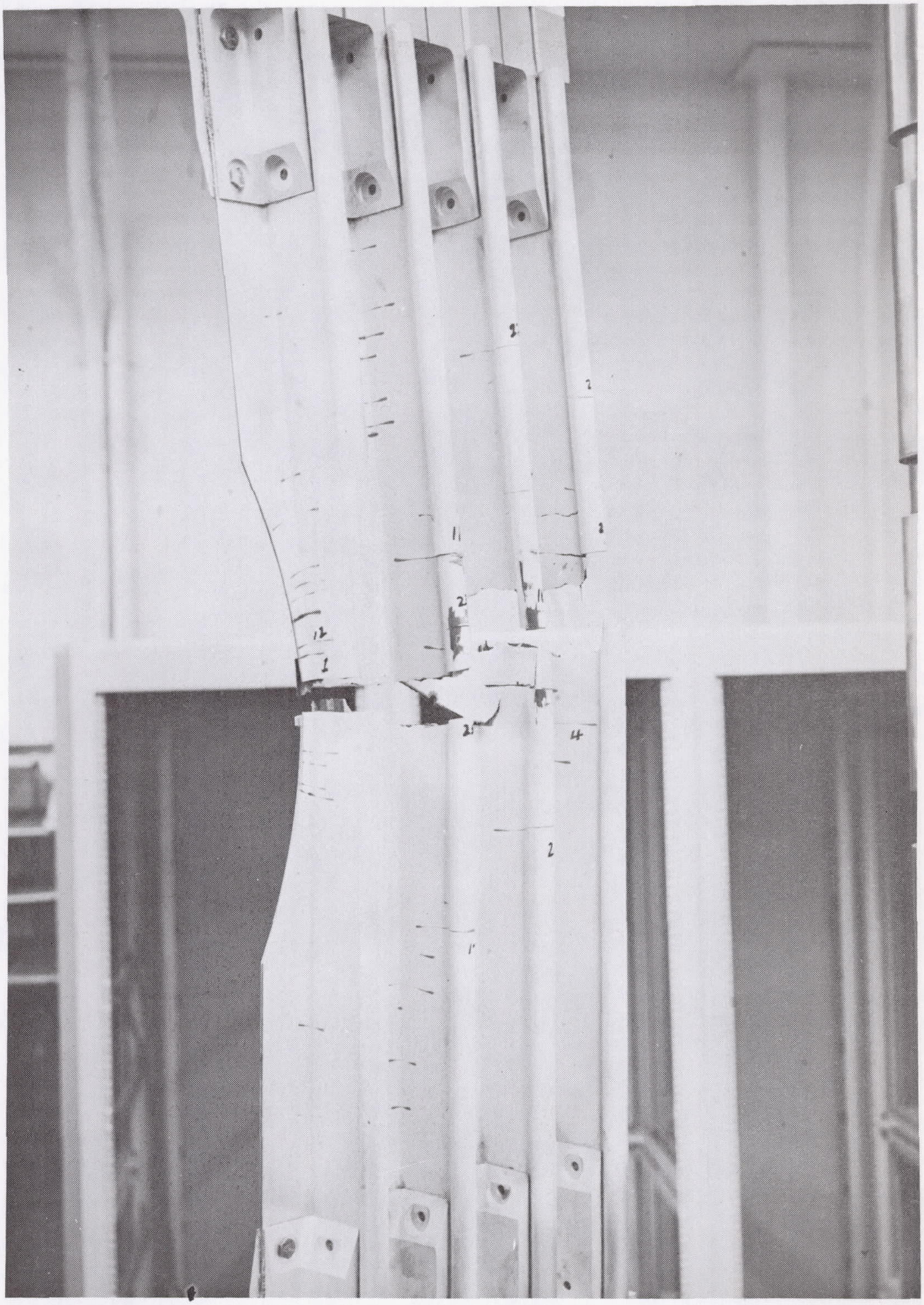

FIGURE F-19 INSIDE STIFFENER SHEET AFTER RESIDUAL STRENGTH TEST - PANEL #5C
(LEFT OF CENTERLINE)

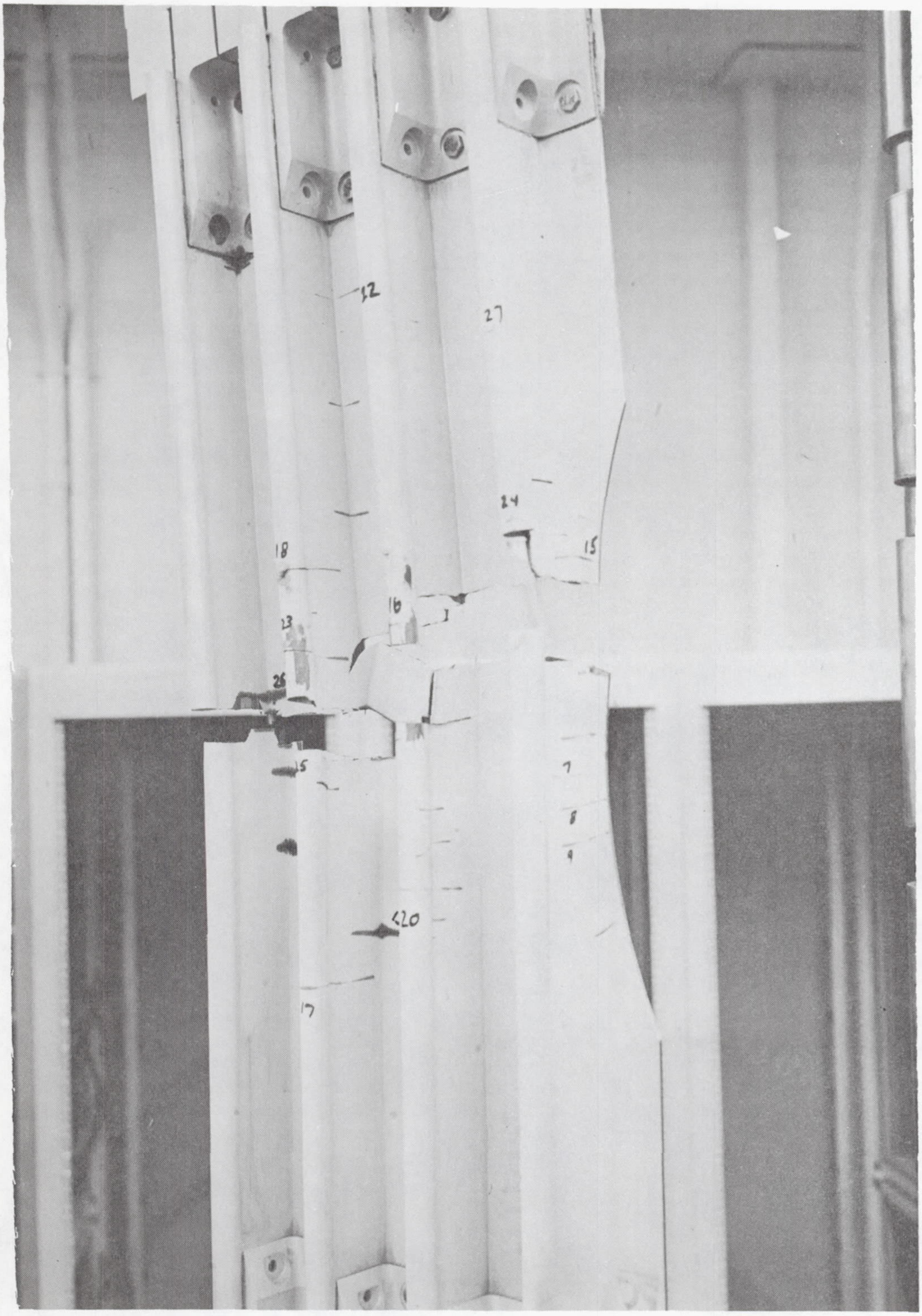

FIGURE F-20 INSIDE STIFFENER SHEET AFTER RESIDUAL STRENGTH TEST - PANEL #5C

(RIGHT OF CENTERLINE)

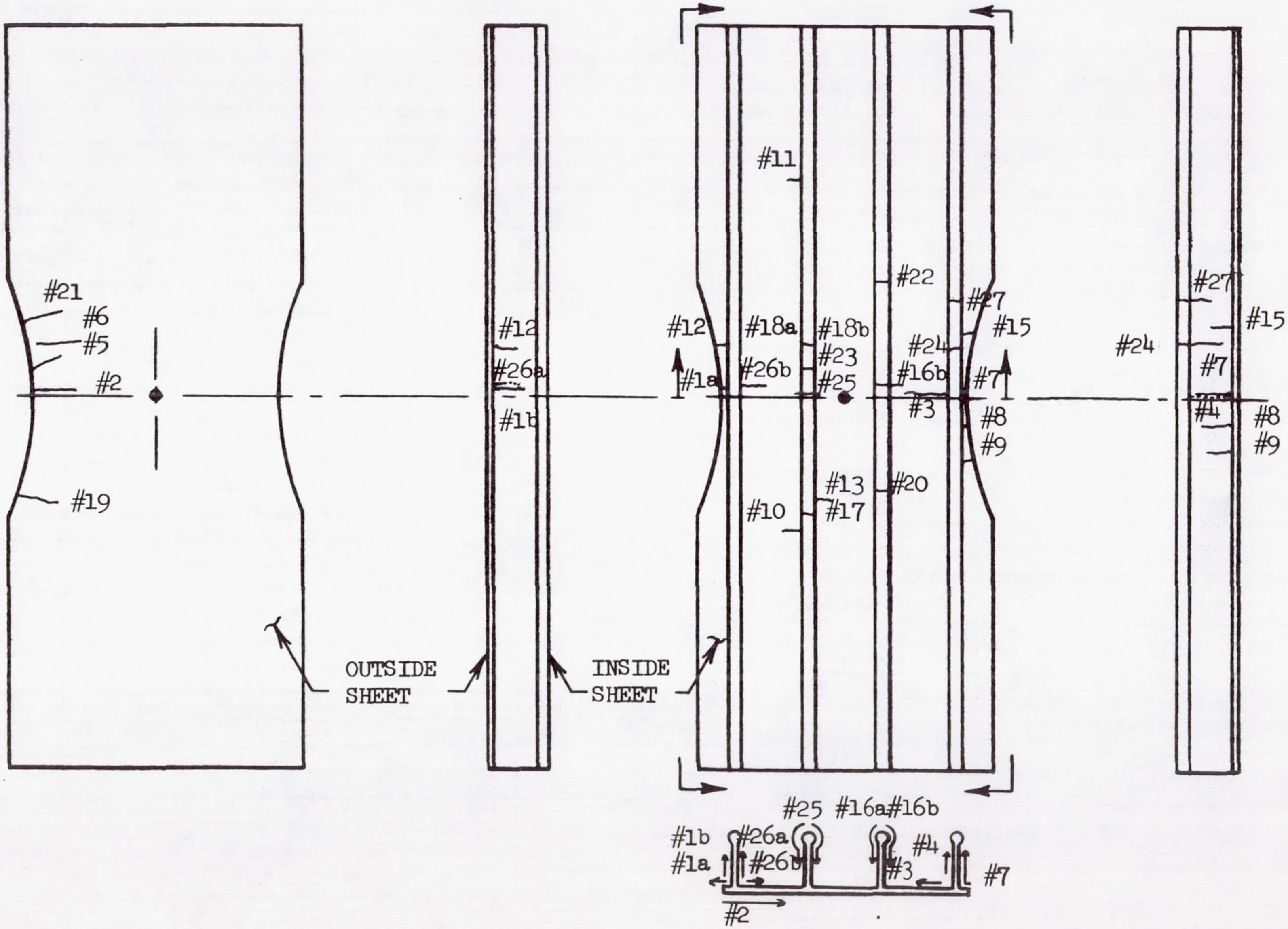

FIGURE F-21 SECONDARY CRACK LOCATIONS
ALUMINUM-GRAPHITE PANEL #5C

Panel No. 5C		Primary Crack Lengths millimeters (inches)				Secondary Crack Lengths millimeters (inches)		
Cycle Rate	No. of Cycles	L/H Outside	R/H Outside	L/H Inside	R/H Inside			
3 Hz	7,820	5.1 (.20)	5.1 (.20)					
3 Hz	10,100		6.4 (.25)					
3 Hz	10,200				3.8 (.15)			
4 Hz	11,600	6.4 (.25)						
	12,400			3.8 (.15)				
	12,600		7.6 (.30)					
	12,800				5.1 (.20)			
	14,350	7.6 (.30)						
	16,500				6.4 (.25)			
	17,300		8.9 (.35)					
	19,300				7.6 (.30)			
	19,500	8.9 (.35)						
	21,200			7.6 (.30)				
	21,400				8.9 (.35)			
	22,100		10.2 (.40)					
	22,300	10.2 (.40)						
	26,000				10.2 (.40)			
	26,200			8.9 (.35)				
	26,500		11.4 (.45)					
	30,300	11.4 (.45)						
	32,400			10.2 (.40)				
	32,700				11.4 (.45)			
	37,500	12.7 (.50)	12.7 (.50)					
	39,500			11.4 (.45)	12.7 (.50)			
	40,900	14.0 (.55)	14.0 (.55)					
	43,500	15.2 (.60)	15.2 (.60)					
	44,000			12.7 (.50)				
	44,800				14.0 (.55)			
	48,450				15.2 (.60)			
	49,000		16.5 (.65)					
	49,600	16.5 (.65)						
4 Hz	50,200			14.0 (.55)				

Panel No. 5C		Primary Crack Lengths millimeters (inches)				Secondary Crack Lengths millimeters (inches)		
Cycle Rate	No. of Cycles	L/H Outside	R/H Outside	L/H Inside	R/H Inside	#1a	#1b	#2
4 Hz	55,600	17.8 (.70)	17.8 (.70)					
	56,800				16.5 (.65)			
	59,300			15.2 (.60)				
	63,000			16.5 (.65)	17.8 (.70)			
	65,890	19.0 (.75)	19.0 (.75)					
	67,260	20.3 (.80)	20.3 (.80)					
	68,740			17.8 (.70)	19.0 (.75)			
	69,590					2.5 (.10)		
	72,390				20.3 (.80)	3.8 (.15)	2.5 (.10)	
	72,690	21.6 (.85)	21.6 (.85)					
	74,090			19.0 (.75)				
	74,190					5.1 (.20)		
	74,490						3.8 (.15)	
	75,890					6.4 (.25)		
	77,290					OFF EDGE	5.1 (.20)	
	78,090	22.9 (.90)	22.9 (.90)			OF PANEL		
	78,890							12.7 (.50)
	79,890			20.3 (.80)	21.6 (.85)			
	80,390							14.0 (.55)
	80,590	24.1 (.95)						
	80,990		24.1 (.95)					
	81,790						6.4 (.25)	
	82,790				22.9 (.90)			
	83,890							15.2 (.60)
	84,590	25.4 (1.00)						
	84,990		25.4 (1.00)					
	85,190			21.6 (.85)			7.6 (.30)	
	85,990							16.5 (.65)
	88,290				24.1 (.95)		8.9 (.35)	
	89,090							
	90,890							17.8 (.70)
4 Hz	91,390					6.4 (.25)		

Panel No. 5C		Secondary Crack Lengths millimeters (inches)						
Cycle Rate	No. of Cycles	#3	#4					
4 Hz	55,600							
	56,800							
	59,300							
	63,000							
	65,890							
	67,260							
	68,740							
	69,590							
	72,390							
	72,690							
	74,090							
	74,190							
	74,490							
	75,890							
	77,290							
	78,090							
	78,890							
	79,890							
	80,390							
	80,590							
	80,990							
	81,790							
	82,790							
	83,890							
	84,590							
	84,990							
	85,190							
	85,990							
	88,290							
	89,090	2.5 (.10)	2.5 (.10)					
	90,890							
4 Hz	91,390		3.8 (.15)					

Panel No. 5C		Primary Crack Lengths millimeters (inches)				Secondary Crack Lengths millimeters (inches)		
Cycle Rate	No. of Cycles	L/H Outside	R/H Outside	L/H Inside	R/H Inside	#1a	#1b	#2
3 Hz	91,490	26.7 (1.05)	26.7 (1.05)			6.4 (.25)		
	92,790			22.9 (.90)				
	92,890				25.4 (1.00)			
	93,690							
	94,390							
	95,290							19.0 (.75)
	95,490	27.9 (1.10)	27.9 (1.10)					
	96,290							20.3 (.80)
	98,090							
	98,490						10.2 (.40)	
	98,590			24.1 (.95)	26.7 (1.05)			
	99,490							21.6 (.85)
	99,890	29.2 (1.15)						
	101,390		29.2 (1.15)					
	103,190							
	104,090							22.9 (.90)
	104,590						12.7 (.50)	
	105,390				27.9 (1.10)			
	106,790							24.1 (.95)
	106,840	30.5 (1.20)						
	107,290							
	107,490			25.4 (1.00)				
	108,390		30.5 (1.20)					
	108,590						14.0 (.55)	
	109,290							
	109,760				29.2 (1.15)			
	110,890							
	110,990							
	111,680							25.4 (1.00)
	112,590							
	112,790							
3 Hz	113,190					6.4 (.25)	15.2 (.60)	

Panel No. 5C		Secondary Crack Lengths millimeters (inches)					
Cycle Rate	No. of Cycles	#3	#4	#7			
3 Hz	91,490						
	92,790						
	92,890						
	93,690		5.1 (.20)				
	94,390	5.1 (.20)					
	95,290						
	95,490						
	96,290						
	98,090		6.4 (.25)				
	98,490						
	98,590						
	99,490						
	99,890						
	101.390						
	103,190		7.6 (.30)				
	104,090						
	104,590						
	105,390	8.9 (.35)	8.9 (.35)				
	106,790						
	106,840						
	107,290		10.2 (.40)				
	107,490						
	108,390						
	108,590						
	109,290		11.4 (.45)				
	109,760						
	110,890			5.1 (.20)			
	110,990	10.2 (.40)					
	111,680						
	112.590			6.4 (.25)			
	112,790		12.7 (.50)				
3 Hz	113,190						

Panel No. 5C		Primary Crack Lengths millimeters (inches)				Secondary Crack Lengths millimeters (inches)		
Cycle Rate	No. of Cycles	L/H Outside	R/H Outside	L/H Inside	R/H Inside	#1a	#1b	#2
2 Hz	113,790	31.8 (1.25)	31.8 (1.25)			6.4 (.25)		
	114,390							
	116,090			26.7 (1.05)				
	116,290							
	116,790							26.7 (1.05)
	117,390							
	117,490							
	117,790							
	117,990				30.5 (1.20)			
	118,090							
	119,290							27.9 (1.10)
	119,790							
	120,090							
	120,290							
	120,560	33.0 (1.30)	33.0 (1.30)				16.5 (.65)	
	121,260			27.9 (1.10)				
	121,960							
	123,320							29.2 (1.15)
	123,760							
	123,960						17.8 (.70)	
	124,460			29.2 (1.15)				
	125,320	34.3 (1.35)	34.3 (1.35)					
	125,660				31.8 (1.25)			
	126,160							
	126,880							30.5 (1.20)
	126,960							
	127,160							
	127,960				33.0 (1.30)			
	128,260						19.0 (.75)	
	128,360							
	128,460		35.6 (1.40)					
2 Hz	129,260					6.4 (.25)		

Panel No. 5C		Secondary Crack Lengths millimeters (inches)						
Cycle Rate	No. of Cycles	#3	#4	#7	#16a	#16b	#18a	#18b
2 Hz	113,790							
	114,390				8.9 (.35)	8.9 (.35)		
	116,090	11.4 (.45)						
	116,290				10.2 (.40)	10.2 (.40)		
	116,790						10.2 (.40)	7.6 (.30)
	117,390						11.4 (.45)	
	117,490							8.9 (.35)
	117,790				12.7 (.50)	12.7 (.50)		
	117,990		15.2 (.60)					
	118,090			7.6 (.30)				
	119,290							
	119,790			8.9 (.35)				
	120,090				14.0 (.55)	14.0 (.55)		
	120,290						12.7 (.50)	10.2 (.40)
	120,560	12.7 (.50)			15.2 (.60)	15.2 (.60)		
	121,260							
	121,960		16.5 (.65)					
	123,320							
	123,760			10.2 (.40)				
	123,960							
	124,460							
	125,320							
	125,660							
	126,160				16.5 (.65)	16.5 (.65)	16.5 (.65)	11.4 (.45)
	126,880							
	126,960			11.4 (.45)				
	127,160				17.8 (.70)			
	127,960							
	128,260			12.7 (.50)	19.0 (.75)		17.8 (.70)	
	128,360		17.8 (.70)					
	128,460							
2 Hz	129,260					17.8 (.70)		

Panel No. 5C		Primary Crack Lengths millimeters (inches)				Secondary Crack Lengths millimeters (inches)		
Cycle Rate	No. of Cycles	L/H Outside	R/H Outside	L/H Inside	R/H Inside	#1a	#1b	#2
2 Hz	129,460					6.4 (.25)		
	130,310							
	130,360	35.6 (1.40)						31.8 (1.25)
	130,860							
	131,860							
	131,960				34.3 (1.35)			
	132,060							
	132,560							33.0 (1.30)
	134,360		36.8 (1.45)					
	134,460			30.5 (1.20)				
	134,560							
	134,660						20.3 (.80)	
	134,760							
	134,860							
	134,960							
	135,160							
	135,260							
	135,560							
	136,660							
	137,660	36.8 (1.45)						
	137,760							34.3 (1.35)
	137,860				35.6 (1.40)			
	138,060			31.8 (1.25)				
	138,260						21.6 (.85)	
	138,460							
	138,760							
	138,860							
	139,760							
	139,860	38.1 (1.50)	38.1 (1.50)					
	139,960							35.6 (1.40)
	140,560							
2 Hz	140,760					6.4 (.25)		

Panel No. 5C		Secondary Crack Lengths millimeters (inches)						
Cycle Rate	No. of Cycles	#3	#4	#7	#16a	#16b	#18a	#18b
2 Hz	129,460							12.7 (.50)
	130,310							
	130,360							
	130,860	14.0 (.55)						
	131,860	16.5 (.65)						
	131,960							
	132,060		20.3 (.80)					
	132,560							
	134,360							
	134,460		21.6 (.85)					
	134,560	19.0 (.75)						
	134,660							
	134,760			17.8 (.70)				
	134,860				21.6 (.85)	20.3 (.80)		
	134,960						20.3 (.80)	
	135,160							16.5 (.65)
	135,260						21.6 (.85)	
	135,560	20.3 (.80)						
	136,660	21.6 (.85)						
	137,660							
	137,760	22.9 (.90)						
	137,860							
	138,060							
	138,260			19.0 (.75)				
	138,460		22.9 (.90)					
	138,760				22.9 (.90)			
	138,860					21.6 (.85)		
	139,760						22.9 (.90)	
	139,860							
	139,960							
	140,560	24.1 (.95)		20.3 (.80)				
2 Hz	140,760		24.1 (.95)					

Panel No. 5C		Primary Crack Lengths millimeters (inches)				Secondary Crack Lengths millimeters (inches)		
Cycle Rate	No. of Cycles	L/H Outside	R/H Outside	L/H Inside	R/H Inside	#1a	#1b	#2
2 Hz	141,660					6.4 (.25)		
	141,760							
	141,860		39.4 (1.55)					
	141,960						22.9 (.90)	
	142,260							
	142,760							
	142,960							
	143,260				36.8 (1.45)			
	144,160			33.0 (1.30)				
	145,660	39.4 (1.55)						
	146,060							36.8 (1.45)
	146,260							
	148,660	40.6 (1.60)	40.6 (1.60)					
	149,060						24.1 (.95)	
	149,160							
	149,260							
	150,560				38.1 (1.50)			
	151,160							
	152,760			34.3 (1.35)	39.4 (1.55)			
	153,060	41.5 (1.65)	41.5 (1.65)					
	153,342							
	154,972							38.1 (1.50)
	156,342							
	156,442				40.6 (1.60)			
	156,542			35.6 (1.40)				
	157,142							
	157,342						27.9 (1.10)	
	157,742							
	158,242	43.2 (1.70)						
	158,442		43.2 (1.70)					
	161,042			36.8 (1.45)	41.5 (1.65)			
2 Hz	161,142					6.4 (.25)	29.2 (1.15)	

Panel No. 5C		Secondary Crack Lengths millimeters (inches)						
Cycle Rate	No. of Cycles	#3	#4	#7	#16a	#16b	#18a	#18b
2 Hz	141,660	25.4 (1.00)						
	141,760				24.1 (.95)	22.9 (.90)		
	141,860							
	141,960							
	142,260						24.1 (.95)	17.8 (.70)
	142,760	26.7 (1.05)	25.4 (1.00)					
	142,960			21.6 (.85)				
	143,260							
	144,160	27.9 (1.10)			25.4 (1.00)	24.1 (.95)		
	145,660							
	146,060							
	146,260	29.2 (1.15)						
	148,660							
	149,060			22.9 (.90)				
	149,160						25.4 (1.00)	19.0 (.75)
	149,260				26.7 (1.05)	26.7 (1.05)		
	150,560							
	151,160		27.9 (1.10)					
	152,760							
	153,060							
	153,342	30.5 (1.20)			27.9 (1.10)	27.9 (1.10)	27.9 (1.10)	20.3 (.80)
	154,972							
	156,342	34.3 (1.35)	29.2 (1.15)					
	156,442							
	156,542							
	157,142				29.2 (1.15)	29.2 (1.15)		
	157,342			27.9 (1.10)			29.2 (1.15)	21.6 (.85)
	157,742							
	158,242							
	158,442							
	161,042							
2 Hz	161,142	36.8 (1.45)		29.2 (1.15)	30.5 (1.20)	30.5 (1.20)		22.9 (.90)

Panel No. 5C		Secondary Crack Lengths millimeters (inches)						
Cycle Rate	No. of Cycles	#26a	#26b					
2 Hz	141,660							
	141,760							
	141,860							
	141,960							
	142,260							
	142,760							
	142,960							
	143,260							
	144,160							
	145,660							
	146,060							
	146,260							
	148,660							
	149,060							
	149,160							
	149,260							
	150,560	11.4 (.45)	10.2 (.40)					
	151,160							
	152,760							
	153,060							
	153,342	12.7 (.50)	11.4 (.45)					
	154,972							
	156,342							
	156,442							
	156,542							
	157,142							
	157,342							
	157,742	15.2 (.60)	12.7 (.50)					
	158,242							
	158,442							
	161,042							
2 Hz	161,142							

Panel No. 5C		Primary Crack Lengths millimeters (inches)				Secondary Crack Lengths millimeters (inches)		
Cycle Rate	No. of Cycles	L/H Outside	R/H Outside	L/H Inside	R/H Inside	#1a	#1b	#2
2 Hz	161,192					6.4 (.25)		
	161,242							
	161,842							
	162,242	44.4 (1.75)	44.4 (1.75)					
	162,442							43.2 (1.70)
	163,642	45.7 (1.80)						
	164,342							
	164,642				43.2 (1.70)			
	164,742			38.1 (1.50)			30.5 (1.20)	
	164,842							
	164,942							
	165,042							
	165,742		45.7 (1.80)					
	167,342							45.7 (1.80)
	167,842	47.0 (1.85)						
	167,942			39.4 (1.55)				
	168,342						31.8 (1.25)	
	168,642							
	168,742							
	169,142							
	169,342		47.0 (1.85)					
	171,542							47.0 (1.85)
	171,742			40.6 (1.60)				
	172,292							
	172,342							
	172,542							
	172,742				44.4 (1.75) OVERLAPS #16a SECONDARY CRACK			
	173,242							
	173,342							
	173,442							
	173,842			41.5 (1.65)				
2 Hz	174,242					6.4 (.25)		48.3 (1.90)

Panel No. 5C		Secondary Crack Lengths millimeters (inches)						
Cycle Rate	No. of Cycles	#3	#4	#7	#16a	#16b	#18a	#18b
2 Hz	161,192		31.8 (1.25)					
	161,242						30.5 (1.20)	
	161,842							
	162,242							
	162,442							
	163,642							
	164,342	38.1 (1.50)	33.0 (1.30)					
	164,642							
	164,742							
	164,842			30.5 (1.20)	31.8 (1.25)	31.8 (1.25)		
	164,942						31.8 (1.25)	24.1 (.95)
	165,042							
	165,742							
	167,342							
	167,842							
	167,942	39.4 (1.55)	34.3 (1.35)					
	168,342							
	168,642			31.8 (1.25)	33.0 (1.30)	33.0 (1.30)		
	168,742						33.0 (1.30)	25.4 (1.00)
	169,142							
	169,342							
	171,542							
	171,742							
	172,292		35.6 (1.40)					
	172,342	41.5 (1.65)						
	172,542			33.0 (1.30)				
	172,742				34.3 (1.35)	34.3 (1.35)		
	173,242				OVERLAPS R/H		35.6 (1.40)	27.9 (1.10)
	173,342				INSIDE PRI-			
	173,442	43.2 (1.70)			MARY CRACK			
	173,842							
2 Hz	174,242							

Panel No. 5C		Secondary Crack Lengths millimeters (inches)						
Cycle Rate	No. of Cycles	#26a	#26b					
2 Hz	161,192							
	161,242							
	161,842	16.5 (.65)	14.0 (.55)					
	162,242							
	162,442							
	163,642							
	164,342							
	164,642							
	164,742							
	164,842							
	164,942							
	165,042	17.8 (.70)	15.2 (.60)					
	165,742							
	167,342							
	167,842							
	167,942							
	168,342							
	168,642							
	168,742							
	169,142	20.3 (.80)	16.5 (.65)					
	169,342							
	171,542							
	171,742							
	172,292							
	172,342							
	172,542							
	172,742							
	173,242							
	173,342	22.9 (.90)	19.0 (.75)					
	173,442							
	173,842							
2 Hz	174,242							

Panel No. 5C		Primary Crack Lengths millimeters (inches)				Secondary Crack Lengths millimeters (inches)		
Cycle Rate	No. of Cycles	L/H Outside	R/H Outside	L/H Inside	R/H Inside	#1a	#1b	#2
2 Hz	174,342	49.5 (1.95)	48.3 (1.90)			6.4 (.25)		
2 Hz	176,452		49.5 (1.95)			6.4 (.25)	34.3 (1.35)	49.5 (1.95)
FINAL CRACK LENGTHS		49.5 (1.95)	49.5 (1.95)	41.5 (1.65)	44.4 (1.75)	6.4 (.25)	34.3 (1.35)	49.5 (1.95)

RESIDUAL STRENGTH = 302,460 N (68,000 lbs.)

Panel No. 5C		Secondary Crack Lengths millimeters (inches)						
Cycle Rate	No. of Cycles	#3	#4	#7	#16a	#16b	#18a	#18b
2 Hz	174,342							
2 Hz	176,452			34.3 (1.35)				
FINAL CRACK LENGTHS		43.2 (1.70)	35.6 (1.40)	34.3 (1.35)	34.3 (1.35)	34.3 (1.35)	35.6 (1.40)	27.9 (1.10)

Panel No. 5C		Secondary Crack Lengths millimeters (inches)						
Cycle Rate	No. of Cycles	#26a	#26b					
2 Hz	174,342							
2 Hz	176,452	24.1 (.95)	21.6 (.85)					
FINAL CRACK LENGTHS		24.1 (.95)	21.6 (.85)					

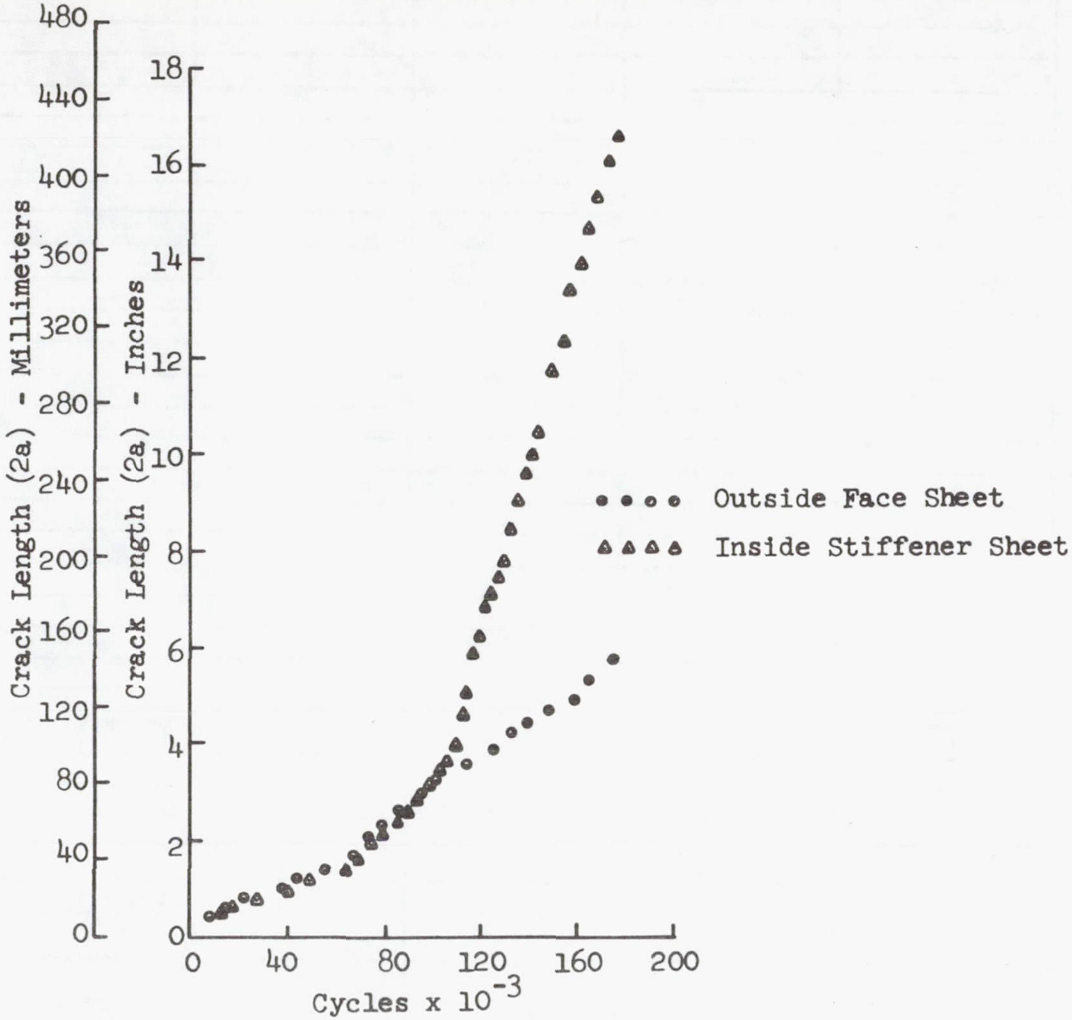

FIGURE F-22 CRACK GROWTH CURVE FOR ALUMINUM-GRAPHITE PANEL #5C
(CRACK LENGTH INCLUDES SECONDARY CRACKS)

PANEL #6C

MATERIALS: ALUMINUM-GRAPHITE

ADHESIVE: AF 126

ALUMINUM STRESS: 138 MN/m^2 (20 ksi)

MAXIMUM FATIGUE LOAD: 164,580N (37,000 lbf)

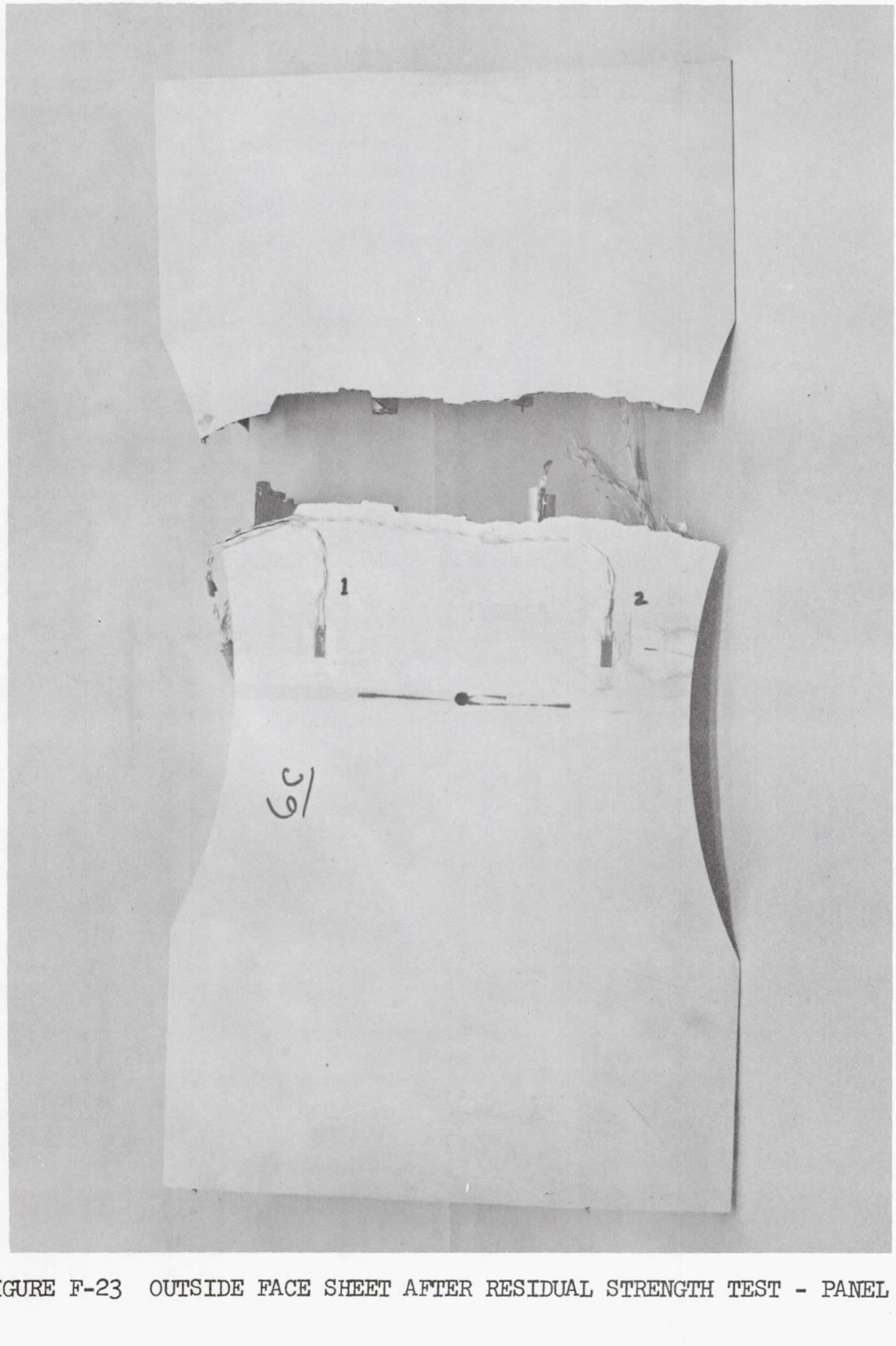

FIGURE F-23 OUTSIDE FACE SHEET AFTER RESIDUAL STRENGTH TEST - PANEL #6C

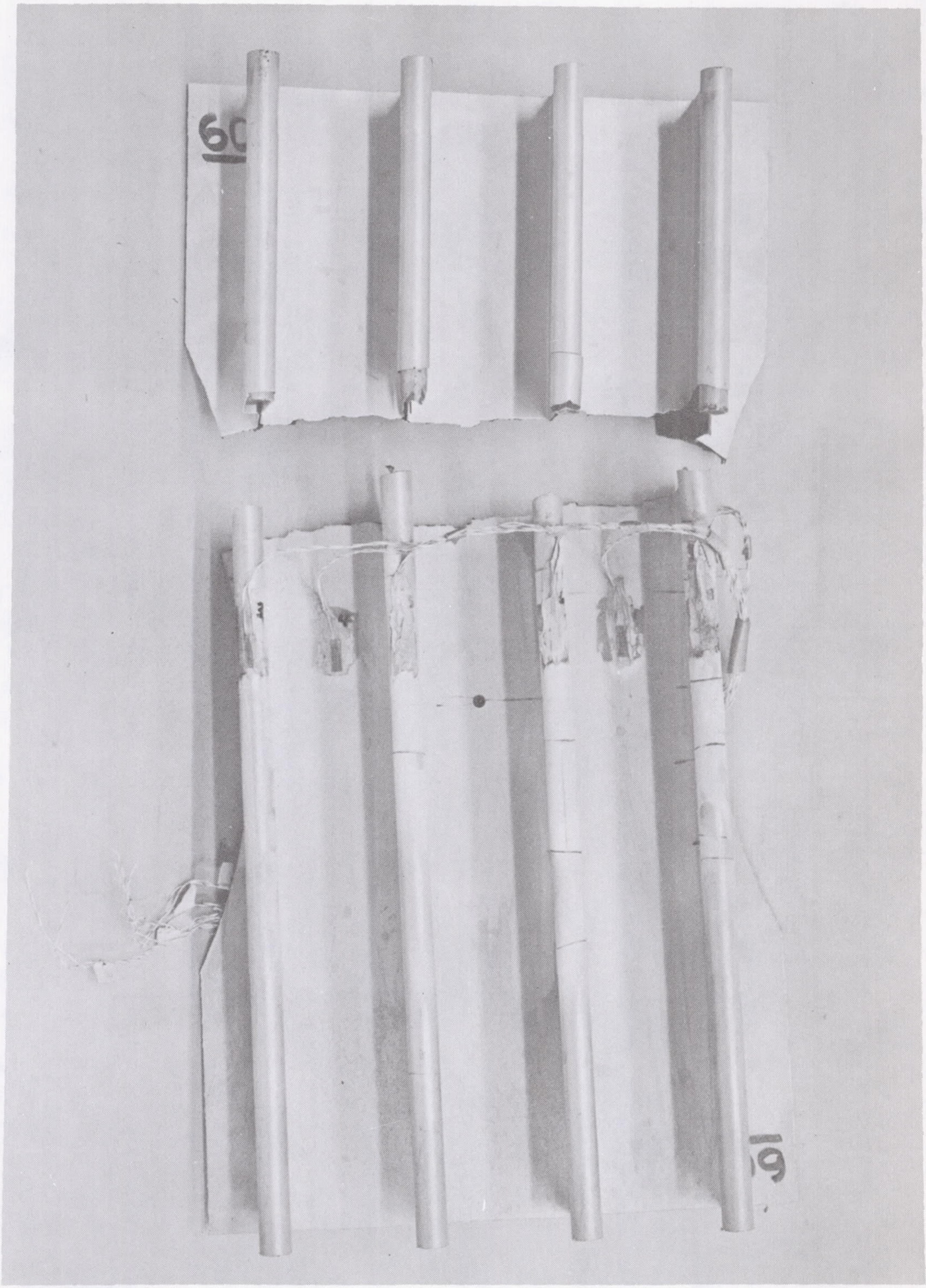

FIGURE F-24 INSIDE STIFFENER SHEET AFTER RESIDUAL STRENGTH TEST - PANEL #6C

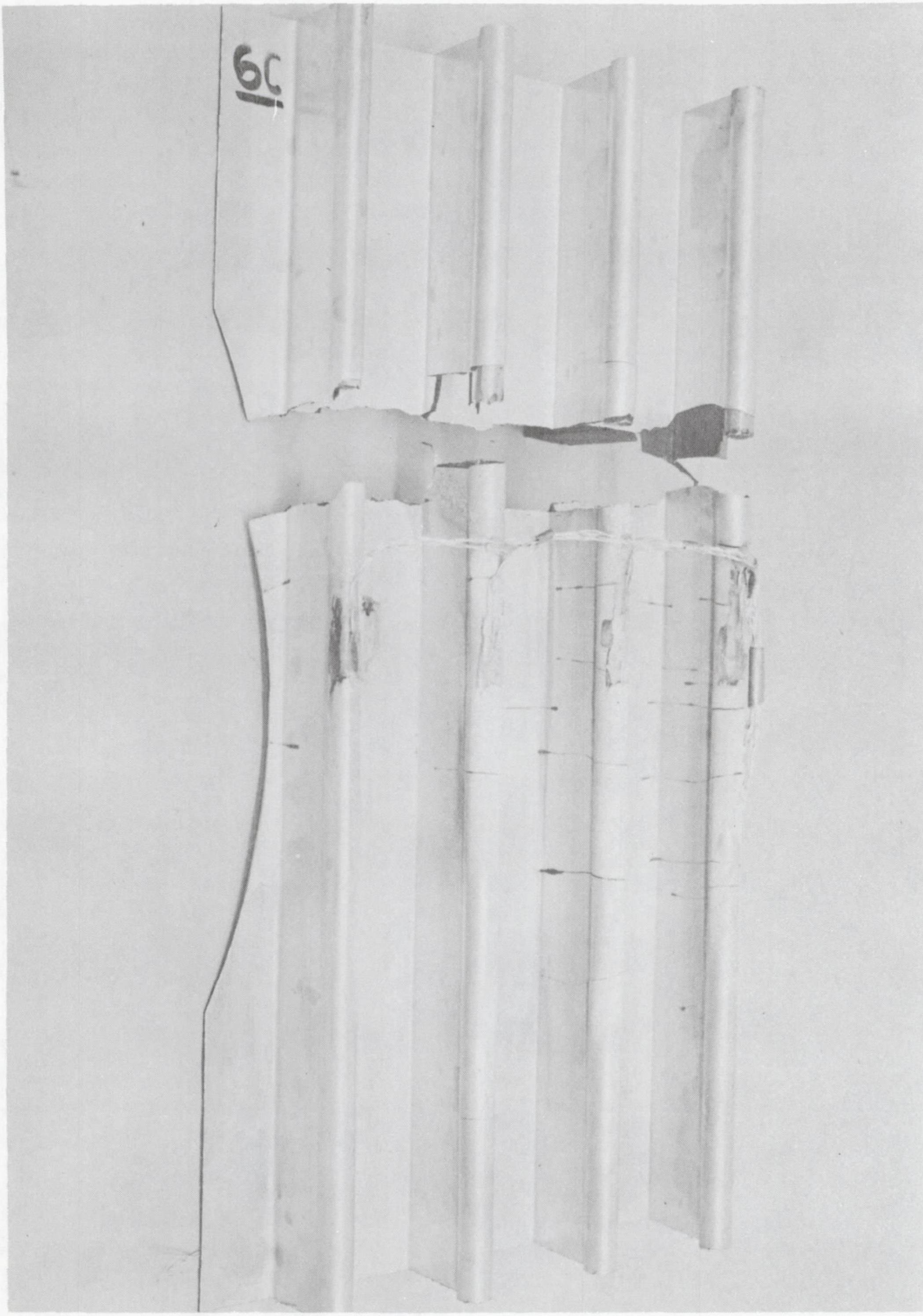

FIGURE F-25 INSIDE STIFFENER SHEET AFTER RESIDUAL STRENGTH TEST - PANEL #6C

(LEFT OF CENTERLINE)

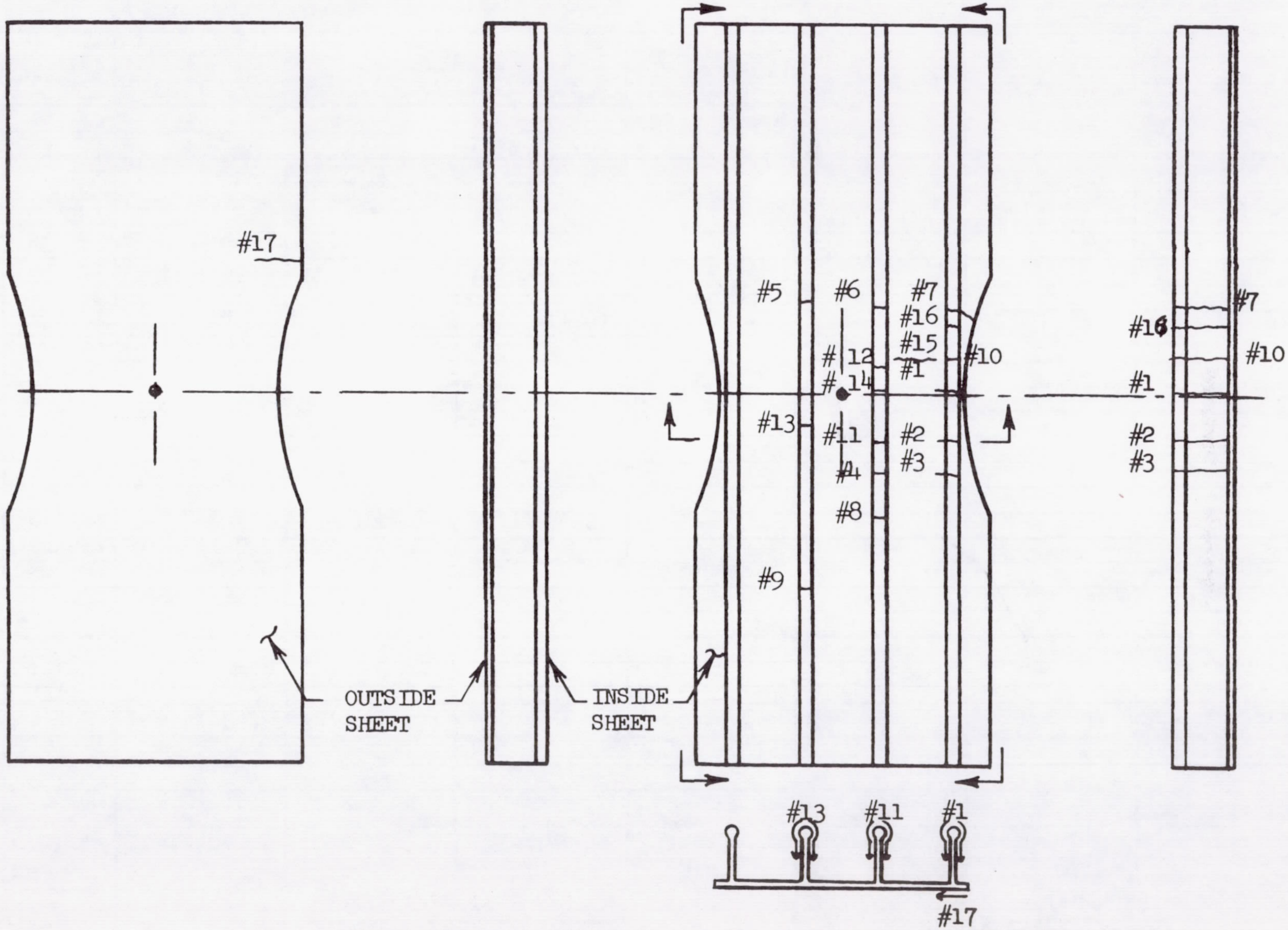

FIGURE F-26 SECONDARY CRACK LOCATIONS
ALUMINUM-GRAPHITE PANEL #6C

Panel No. 6C		Primary Crack Lengths millimeters (inches)				Secondary Crack Lengths millimeters (inches)		
Cycle Rate	No. of Cycles	L/H Outside	R/H Outside	L/H Inside	R/H Inside			
3Hz	7,400	3.8 (.15)						
5Hz	9,027	5.1 (.20)						
	9,577				3.8 (.15)			
	12,827	6.4 (.25)	3.8 (.15)					
	13,127				5.1 (.20)			
	17,927	7.6 (.30)						
	18,627		5.1 (.20)					
	18,927			5.1 (.20)	6.4 (.25)			
	19,927	8.9 (.35)						
	20,427				7.6 (.30)			
	24,627	10.2 (.40)	6.4 (.25)					
	24,727			6.4 (.25)				
	24,927				8.9 (.35)			
	25,927		7.6 (.30)					
	29,527		8.9 (.35)					
	29,727	11.4 (.45)						
	29,927			7.6 (.30)				
	30,427				10.2 (.40)			
	38,127	12.7 (.50)	10.2 (.40)					
	38,227			8.9 (.35)				
	38,327				11.4 (.45)			
	44,581	14.0 (.55)	11.4 (.45)	10.2 (.40)	12.7 (.50)			
	48,527	15.2 (.60)						
	48,927			11.4 (.45)	14.0 (.55)			
	49,127		12.7 (.50)					
	53,727	16.5 (.65)	14.0 (.55)					
	53,927			12.7 (.50)				
	54,127				15.2 (.60)			
	60,927	17.8 (.70)	15.2 (.60)	14.0 (.55)				
	61,127				16.5 (.65)			
5 Hz	65,727	19.0 (.75)	16.5 (.65)					

Panel No. 6C		Primary Crack Lengths millimeters (inches)				Secondary Crack Lengths millimeters (inches)		
Cycle Rate	No. of Cycles	L/H Outside	R/H Outside	L/H Inside	R/H Inside	#1 L/H	#1 R/H	
5Hz	66,127			15.2 (.60)				
	66,427				17.8 (.70)			
	70,427		17.8 (.70)					
	75,227	20.3 (.80)						
	75,727			16.5 (.65)				
	75,927		19.0 (.75)					
	76,927				19.0 (.75)			
	80,727	21.6 (.85)						
	80,927			17.8 (.70)				
	85,727		20.3 (.80)					
	87,927	22.9 (.90)						
	88,227			19.0 (.75)	20.3 (.80)			
	89,927		21.6 (.85)					
	90,927					10.2 (.40)	16.5 (.65)	
	94,930	24.1 (.95)	22.9 (.90)					
	95,430			20.3 (.80)	21.6 (.85)	12.7 (.50)	17.8 (.70)	
	98,680			21.6 (.85)				
	98,930					14.0 (.55)	20.3 (.80)	
	99,130		24.1 (.95)					
	100,830				22.9 (.90)			
	102,930	25.4 (1.00)						
	103,930			22.9 (.90)				
	104,830		25.4 (1.00)					
	104,930					15.2 (.60)	22.9 (.90)	
	107,630	26.7 (1.05)						
	107,730			24.1 (.95)	24.1 (.95)			
	107,930					16.5 (.65)	24.1 (.95)	
	108,630		26.7 (1.05)					
	110,930						25.4 (1.00)	
	111,930	27.9 (1.10)						
	112,630			25.4 (1.00)	25.4 (1.00)			
5Hz	113,430		27.9 (1.10)					

Panel No. 6C		Primary Crack Lengths millimeters (inches)				Secondary Crack Lengths millimeters (inches)		
Cycle Rate	No. of Cycles	L/H Outside	R/H Outside	L/H Inside	R/H Inside	#1 L/H	#1 R/H	#11 L/H
5Hz	116,930						27.9 (1.10)	
	117,930			26.7 (1.05)		17.8 (.70)		
	119,430					20.3 (.80)		
	119,630	29.2 (1.15)	29.2 (1.15)					
	122,630							20.3 (.80)
	123,330					21.6 (.85)	30.5 (1.20)	
	123,530			27.9 (1.10)	26.7 (1.05)			
	124,330	30.5 (1.20)	30.5 (1.20)					
	126,430			29.2 (1.15)				
	130,730	31.8 (1.25)						
	130,830		31.8 (1.25)					
	130,930					22.9 (.90)		
	131,430			30.5 (1.20)	27.9 (1.10)			
	131,530							22.8 (.90)
	131,630						33.0 (1.30)	
	134,130		33.0 (1.30)					
	137,830	33.0 (1.30)						
	137,930			31.8 (1.25)	29.2 (1.15)			24.1 (.95)
	138,530					25.4 (1.00)	34.3 (1.35)	
	141,930		34.3 (1.35)					
	143,430	34.3 (1.35)		33.0 (1.30)				
	143,930				30.5 (1.20)			26.7 (1.05)
	144,430					26.7 (1.05)	36.8 (1.45)	
	147,830		35.6 (1.40)					
	148,130	35.6 (1.40)						27.9 (1.10)
	148,730					27.9 (1.10)		
	148,930			34.3 (1.35)				
	153,330		36.8 (1.45)					
	153,930			35.6 (1.40)	31.8 (1.25)			
	156,530							
	156,730					29.2 (1.15)	39.4 (1.55)	
5Hz	157,830	36.8 (1.45)	38.1 (1.50)					

Panel No. 6C		Secondary Crack Lengths millimeters (inches)						
Cycle Rate	No. of Cycles	#13 L/H	#13 R/H					
5Hz	116,930							
	117,930							
	119,430							
	119,630							
	122,630							
	123,330							
	123,530							
	124,330							
	126,430							
	130,730							
	130,830							
	130,930							
	131,430							
	131,530							
	131,630							
	134,130							
	137,830							
	137,930							
	138,530							
	141,930							
	143,430							
	143,930							
	144,430							
	147,830							
	148,130							
	148,730							
	148,930							
	153,330							
	153,930							
	156,530	6.4 (.25)	8.9 (.35)					
	156,730							
5Hz	157,830							

Panel No. 6C		Primary Crack Lengths millimeters (inches)				Secondary Crack Lengths millimeters (inches)		
Cycle Rate	No. of Cycles	L/H Outside	R/H Outside	L/H Inside	R/H Inside	#1 L/H	#1 R/H	#11 L/H
5Hz	161,430	38.1 (1.50)						
	161,930					30.5 (1.20)	40.6 (1.60)	30.5 (1.20)
	164,530		39.4 (1.55)					
	167,730				33.0 (1.30)			
	167,930			36.8 (1.45)				
	168,130	39.4 (1.55)						
	173,730		40.6 (1.60)					
	173,930					33.0 (1.30)	43.2 (1.70)	34.3 (1.35)
	174,530			38.1 (1.50)	34.3 (1.35)			
	184,894	41.9 (1.65)	43.2 (1.70)	39.4 (1.55)	35.6 (1.40)	35.6 (1.40)	45.7 (1.80)	35.6 (1.40)
	193,594						47.0 (1.85)	
	194,894		44.4 (1.75)				Crack	
	196,394					36.8 (1.45)	Ends at	36.8 (1.45)
	196,494	43.2 (1.70)					Edge of	
	200,994	44.4 (1.75)					Specimen	
	204,194		45.7 (1.80)					
	208,194					38.1 (1.50)		38.1 (1.50)
	208,494	45.7 (1.80)						
	209,094		47.0 (1.85)					
	213,894					43.2 (1.70)		
	214,394							
	214,894							
	216,294			44.4 (1.75)				
	216,894		48.3 (1.90)					
	217,194				40.6 (1.60)			Overlaps R/H
	217,894	47.0 (1.85)			Overlaps #11	L/H		Primary
	219,894		49.5 (1.95)		Secondary			Crack
	220,294				Crack			39.4 (1.55)
	220,894			47.0 (1.85)	41.9 (1.65)			
	222,894							
	223,194	48.3 (1.90)						
5Hz	223,694		50.8 (2.00)				47.0 (1.85)	

Panel No. 6C		Secondary Crack Lengths millimeters (inches)						
Cycle Rate	No. of Cycles	#13 L/H	#13 R/H					
5 Hz	161,430							
	161,930	8.9 (.35)	11.4 (.45)					
	164,530							
	167,730							
	167,930							
	168,130							
	173,730							
	173,930	11.4 (.45)	14.0 (.55)					
	174,530							
	184,894	14.0 (.55)	16.5 (.65)					
	193,594							
	194,894							
	196,394							
	196,494							
	200,994							
	204,194							
	208,194	19.0 (.75)	21.6 (.85)					
	208,494							
	209,094							
	213,894							
	214,394	21.6 (.85)						
	214,894		22.9 (.90)					
	216,294							
	216,894							
	217,194							
	217,894							
	219,894							
	220,294							
	220,894							
	222,894	22.9 (.90)						
	223,194							
5 Hz	223,694							

Panel No. 6C		Primary Crack Lengths millimeters (inches)				Secondary Crack Lengths millimeters (inches)		
Cycle Rate	No. of Cycles	L/H Outside	R/H Outside	L/H Inside	R/H Inside	#1 L/H	#1 R/H	#11 L/H
4Hz	226,294						47.0 (1.85)	
	227,594							
	227,894				43.2 (1.70)			
	228,894							40.6 (1.60)
	228,994							
	229,394					44.4 (1.75)		
	229,994							
	230,494	49.5 (1.95)						
	233,094		52.1 (2.05)					
	234,694							
	235,194				44.4 (1.75)			
	235,594	50.8 (2.00)						
	236,394			48.3 (1.90)				
	236,594							
	239,094							41.9 (1.65)
	239,294				45.7 (1.80)			
	239,394							
	239,894							
4Hz	240,294		53.3 (2.10)					
5Hz	241,094					47.0 (1.85)		
	241,594							
	243,494	52.1 (2.05)						
	243,894			49.5 (1.95)				
	244,194		←	Overlaps				
	244,594			#13 R/H				
	245,094			Secondary	45.7 (1.80)			
	246,194			Crack		48.3 (1.90)		
	246,494							43.2 (1.70)
	247,894		54.6 (2.15)					
	249,394							
	249,694	53.3 (2.10)						
4Hz	251,194		55.9 (2.20)				47.0 (1.85)	

Panel No. 6C		Secondary Crack Lengths millimeters (inches)						
Cycle Rate	No. of Cycles	#13 L/H	#13 R/H	#14 R/H				
4Hz	226,294		25.4 (1.00)					
	227,594			25.4 (1.00)				
	227,894							
	228,894							
	228,994	24.1 (.95)						
	229,394							
	229,994		26.7 (1.05)					
	230,494							
	233,094							
	234,694			26.7 (1.05)				
	235,194							
	235,594							
	236,394							
	236,594		27.9 (1.10)					
	239,094							
	239,294							
	239,394	25.4 (1.00)						
	239,894			27.9 (1.10)				
4Hz	240,294							
5Hz	241,094							
	241,594	26.7 (1.05)						
	243,494							
	243,894							
	244,194		29.2 (1.15)					
	244,594		Overlaps L/H	29.2 (1.15)				
	245,094		Primary					
	246,194		Crack					
	246,494							
	247,894							
	249,394	27.9 (1.10)						
	249,694							
4Hz	251,194							

Panel No. 6C		Primary Crack Lengths millimeters (inches)				Secondary Crack Lengths millimeters (inches)		
Cycle Rate	No. of Cycles	L/H Outside	R/H Outside	L/H Inside	R/H Inside	#1 L/H	#1 R/H	#11 L/H
5Hz	253,694						47.0 (1.85)	
	253,894							
	254,194			50.8 (2.00)				
	254,294	54.6 (2.15)						
5Hz	254, 394					49.5 (1.95)	47.0 (1.85)	
Final Crack LENGTHS		54.6 (2.15)	55.9 (2.20)	50.8 (2.00)	45.7 (1.80)	49.5 (1.95)	47.0 (1.85)	43.2 (1.70)

Residual Strength - Not Recorded

Panel No. 6C		Secondary Crack Lengths millimeters (inches)						
Cycle Rate	No. of Cycles	#13 L/H	#13 R/H	#14 R/H	#15			
5Hz	253,694		30.5 (1.20)		No Crack			
	253,894			30.5 (1.20)	Growth			
	254,194				Data			
	254,294				Recorded			
5Hz	254, 394							
FINAL CRACK LENGTHS		27.9 (1.10)	30.5 (1.20)	30.5 (1.20)	76.2 (3.00)			

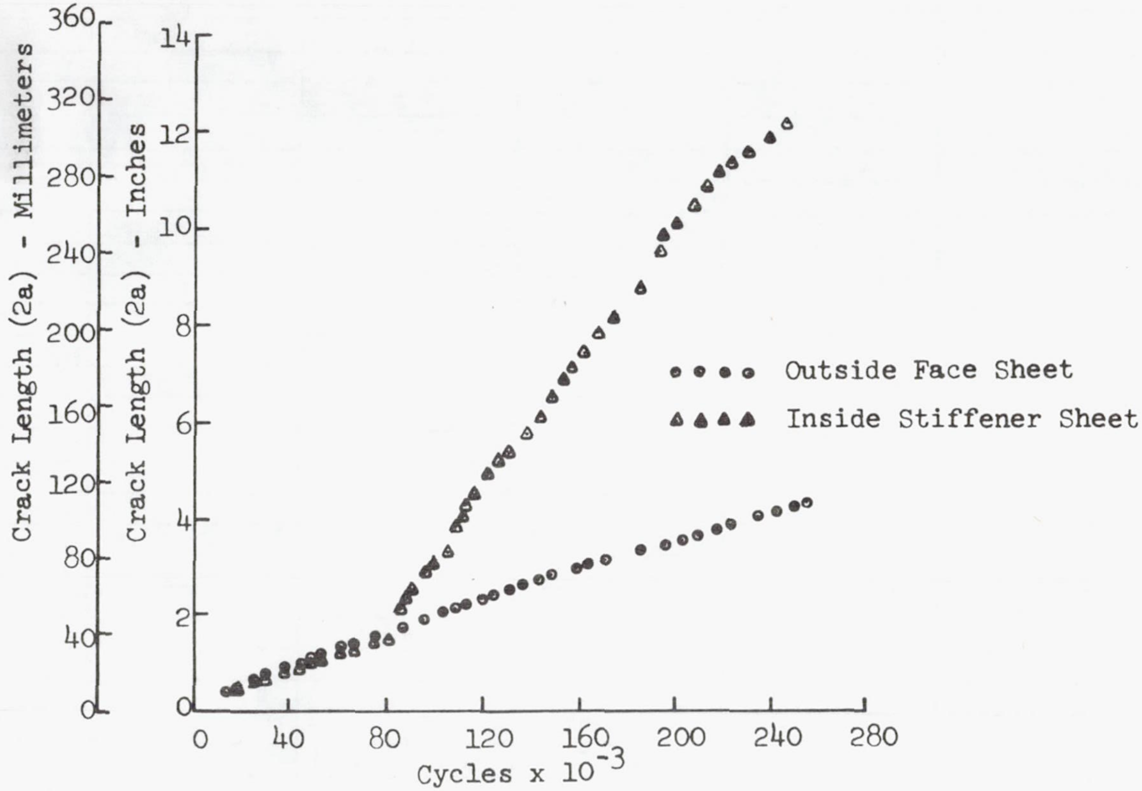

FIGURE F-27 CRACK GROWTH CURVE FOR ALUMINUM-GRAPHITE PANEL #6C
(CRACK LENGTH INCLUDES SECONDARY CRACKS)

PANEL #7C

MATERIALS: ALUMINUM-GRAPHITE

ADHESIVE: AF 126

ALUMINUM STRESS: 103 MN/m^2 (15 ksi)

MAXIMUM FATIGUE LOAD: 124,540N (28,000 lbf)

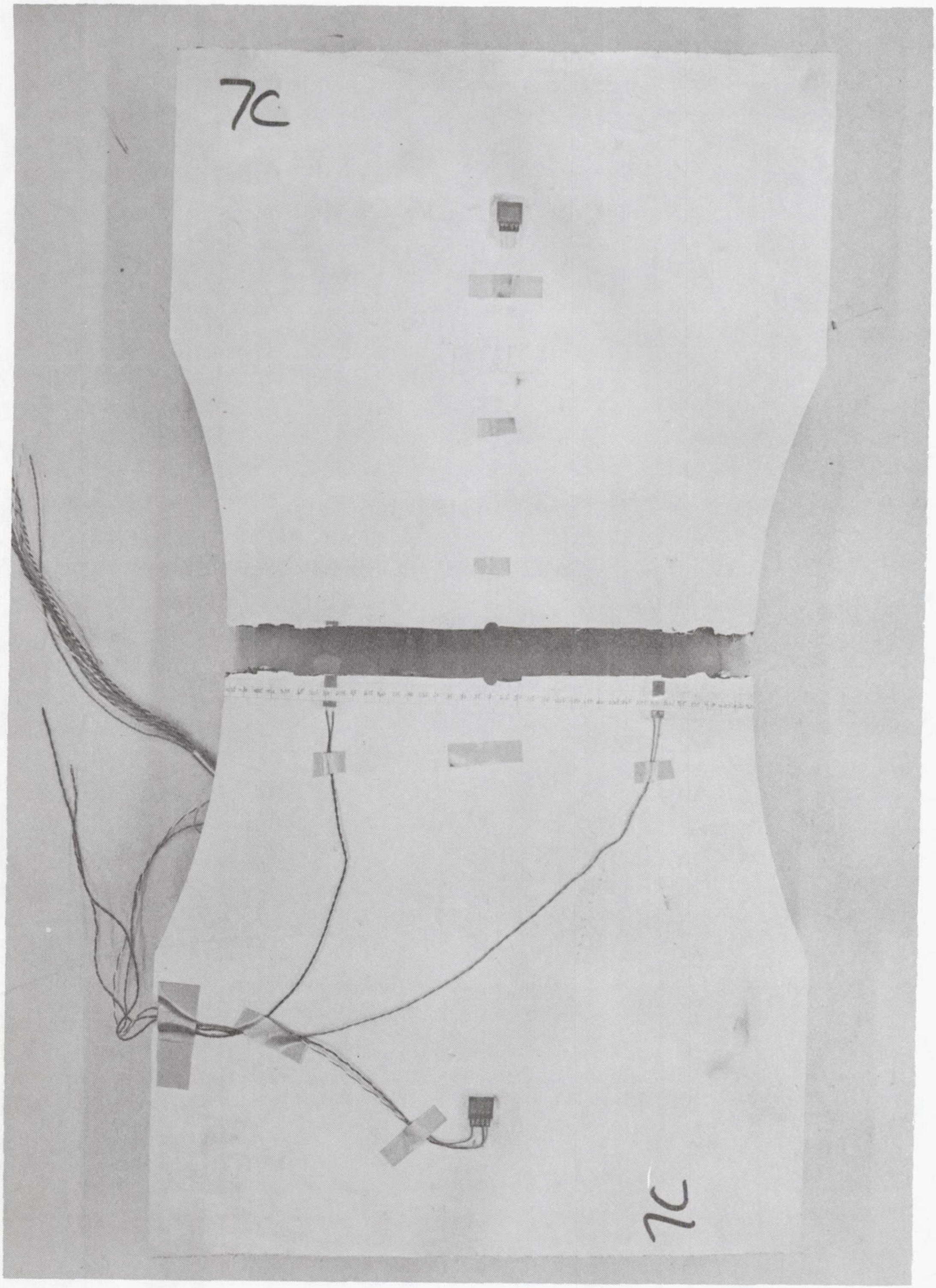

FIGURE F-28 OUTSIDE FACE SHEET AFTER RESIDUAL STRENGTH TEST - PANEL #7C

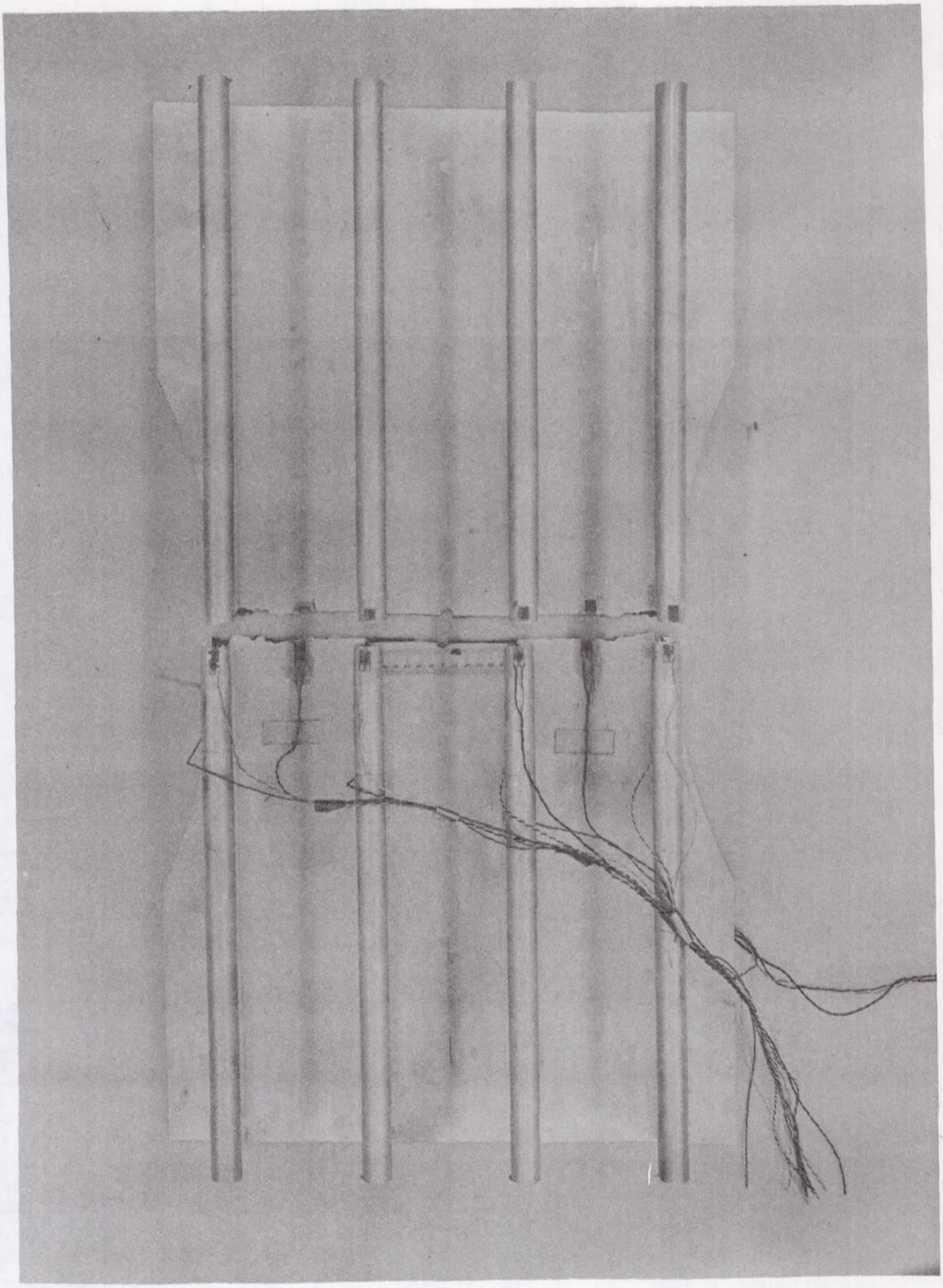

FIGURE F-29 INSIDE STIFFENER SHEET AFTER RESIDUAL STRENGTH TEST - PANEL #7C

Panel No. 7C		Primary Crack Lengths millimeters (inches)				Secondary Crack Lengths millimeters (inches)		
Cycle Rate	No. of Cycles	L/H Outside	R/H Outside	L/H Inside	R/H Inside			
6Hz	32,000	3.8 (.15)						
	34,000				5.1 (.20)			
	40,000	5.1 (.20)						
	42,000				6.4 (.25)			
	45,000	6.4 (.25)						
6Hz	46,000				7.6 (.30)			
7Hz	50,556							
	55,056	7.6 (.30)						
	55,156			5.1 (.20)	8.9 (.35)			
	60,556			6.4 (.25)				
	70,056		3.8 (.15)					
	72,256	8.9 (.35)						
	73,056			7.6 (.30)	10.2 (.40)			
	78,056		5.1 (.20)					
	78,456			8.9 (.35)				
	85,056	10.2 (.40)						
	85,556		6.4 (.25)					
	86,056			10.2 (.40)	11.4 (.45)			
	92,256		7.6 (.30)					
	98,056	11.4 (.45)						
	99,056		8.9 (.35)					
	102,056			11.4 (.45)				
	107,056				14.0 (.55)			
	112,056	12.7 (.50)	10.2 (.40)	12.7 (.50)				
	127,156				15.2 (.60)			
	127,856	14.0 (.55)	11.4 (.45)					
	127,956			14.0 (.55)				
	135,056			15.2 (.60)				
	135,456				16.5 (.65)			
	143,756	15.2 (.60)	12.7 (.50)					
	154,056			16.5 (.65)	17.8 (.70)			
7Hz	159,216	16.5 (.65)	14.0 (.55)	17.8 (.70)				

Panel No. 7C		Primary Crack Lengths millimeters (inches)				Secondary Crack Lengths millimeters (inches)		
Cycle Rate	No. of Cycles	L/H Outside	R/H Outside	L/H Inside	R/H Inside			
7Hz	163,316		15.2 (.60)					
	164,216			19.0 (.75)	19.0 (.75)			
	180,616				20.3 (.80)			
	180,716	17.8 (.70)						
	190,936			20.3 (.80)				
	197,516			21.6 (.85)	21.6 (.85)			
	205,716	19.0 (.75)	16.5 (.65)					
	212,716			22.9 (.90)	22.9 (.90)			
	220,816	20.3 (.80)	17.8 (.70)					
	227,216			24.1 (.95)	24.1 (.95)			
	241,666	21.6 (.85)	19.0 (.75)	25.4 (1.00)	25.4 (1.00)			
	254,566			26.7 (1.05)				
	258,366				26.7 (1.05)			
	258,866	22.9 (.90)						
	266,166		20.3 (.80)					
	267,566			27.9 (1.10)				
	277,166			29.2 (1.15)				
	280,666				27.9 (1.10)			
	281,066	24.1 (.95)						
	289,266		21.6 (.85)					
	295,166				29.2 (1.15)			
	308,366	25.4 (1.00)		30.5 (1.20)				
	317,066		22.9 (.90)					
	317,566			31.8 (1.25)	30.5 (1.20)			
	337,566	26.7 (1.05)						
	338,566			33.0 (1.30)	31.8 (1.25)			
	347,566		24.1 (.95)					
	347,766				33.0 (1.30)			
	356,066	27.9 (1.10)						
	356,566			34.3 (1.35)				
	371,066	29.2 (1.15)	25.4 (1.00)					
7Hz	371,466			35.6 (1.40)				

Panel No. 7C		Primary Crack Lengths millimeters (inches)				Secondary Crack Lengths millimeters (inches)		
Cycle Rate	No. of Cycles	L/H Outside	R/H Outside	L/H Inside	R/H Inside			
7Hz	380,271				34.3 (1.35)			
	395,271	30.5 (1.20)						
	396,271		26.7 (1.05)					
	403,271			36.8 (1.45)				
	409,871	31.8 (1.25)	27.9 (1.10)					
	431,271	33.0 (1.30)	29.2 (1.15)					
	434,450			38.1 (1.50)	35.6 (1.40)			
	449,271				36.8 (1.45)			
	452,771	34.3 (1.35)	30.5 (1.20)	39.4 (1.55)				
	466,471	35.6 (1.40)		40.6 (1.60)	38.1 (1.50)			
	473,271		31.8 (1.25)					
	483,271	36.8 (1.45)						
	484,271			41.9 (1.65)				
	495,671		33.0 (1.30)	43.2 (1.70)				
	512,619	38.1 (1.50)	34.3 (1.35)	44.4 (1.75)	40.6 (1.60)			
	522,419	39.4 (1.55)		45.7 (1.80)	41.9 (1.65)			
	534,119	40.6 (1.60)	35.6 (1.40)					
	534,619			47.0 (1.85)	43.2 (1.70)			
	545,619		36.8 (1.45)		44.4 (1.75)			
	546,619	41.9 (1.65)						
	562,951			48.3 (1.90)	45.7 (1.80)			
	569,951		38.1 (1.50)					
	574,619		39.4 (1.55)					
	576,619	43.2 (1.70)						
	577,119			49.5 (1.95)	47.0 (1.85)			
	589,219	44.4 (1.75)	40.6 (1.60)					
	589,619			50.8 (2.00)	48.3 (1.90)			
	600,919		41.9 (1.65)	52.1 (2.05)	49.5 (1.95)			
	619,619	45.7 (1.80)	43.2 (1.70)					
	620,619			53.3 (2.10)				
	637,919	47.0 (1.85)	44.4 (1.75)	54.6 (2.15)				
7Hz	644,677				50.8 (2.00)			

Panel No. 7C		Primary Crack Lengths millimeters (inches)				Secondary Crack Lengths millimeters (inches)		
Cycle Rate	No. of Cycles	L/H Outside	R/H Outside	L/H Inside	R/H Inside			
7Hz	654,477			55.9 (2.20)				
	654,527	48.3 (1.90)						
	667,077		45.7 (1.80)					
	676,477	49.5 (1.95)	47.0 (1.85)					
	676,677			57.2 (2.25)				
	697,777	50.8 (2.00)	48.3 (1.90)					
	703,583				52.1 (2.05)			
	703,677			58.4 (2.30)				
	728,677		49.5 (1.95)					
	729,177	52.1 (2.05)						
	742,677	53.3 (2.10)						
	742,877		50.8 (2.00)					
	754,077		52.1 (2.05)					
	754,477	54.6 (2.15)						
	754,677			59.7 (2.35)				
	755,177				53.3 (2.10)			
	775,877	55.9 (2.20)	53.3 (2.10)					
	776,318			62.2 (2.45)	55.9 (2.20)			
	789,718		54.6 (2.15)		57.2 (2.25)			
	807,318	57.2 (2.25)						
	808,318		55.9 (2.20)	63.5 (2.50)				
	823,418	58.4 (2.30)	57.2 (2.25)	64.8 (2.55)	58.4 (2.30)			
	839,318	59.7 (2.35)						
	851,218	61.0 (2.40)	58.4 (2.30)					
	851,318			66.0 (2.60)	59.7 (2.35)			
	863,318			67.3 (2.65)				
	865,318		59.7 (2.35)					
	872,318			68.6 (2.70)				
	878,318	62.2 (2.45)	61.0 (2.40)					
	880,318				61.0 (2.40)			
	881,118			69.8 (2.75)				
7Hz	889,818	63.5 (2.50)		71.1 (2.80)	62.2 (2.45)			

Panel No. 7C		Primary Crack Lengths millimeters (inches)				Secondary Crack Lengths millimeters (inches)		
Cycle Rate	No. of Cycles	L/H Outside	R/H Outside	L/H Inside	R/H Inside			
7Hz	897,818		62.2 (2.45)					
	911,118	64.8 (2.55)	63.5 (2.50)					
	911,818			72.4 (2.85)	63.5 (2.50)			
	929,818			73.7 (2.90)	64.8 (2.55)			
	934,818	66.0 (2.60)	64.8 (2.55)					
	941,908			74.9 (2.95)	66.0 (2.60)			
	949,718	67.3 (2.65)	66.0 (2.60)					
	962,118			76.2 (3.00)	67.3 (2.65)			
	963,918	68.6 (2.70)	67.3 (2.65)					
	968,818				68.6 (2.70)			
	977,218		68.6 (2.70)	77.5 (3.05)	69.8 (2.75)			
	992,818	69.8 (2.75)	69.8 (2.75)					
	993,818				71.1 (2.80)			
	1,011,818	71.1 (2.80)	71.1 (2.80)					
	1,012,718				73.7 (2.90)			
7Hz	1,020,520				74.9 (2.95)			
FINAL CRACK LENGTHS		71.1 (2.80)	71.1 (2.80)	77.5 (3.05)	74.9 (2.95)			
RESIDUAL STRENGTH = 539,100 N (121,200 lbs.)								

PANEL #8C

MATERIALS: ALUMINUM - GLASS

ADHESIVE: AF 126

ALUMINUM STRESS: 103 MN/m^2 (15 ksi)

MAXIMUM FATIGUE LOAD: 84,510N (19,000 lbf)

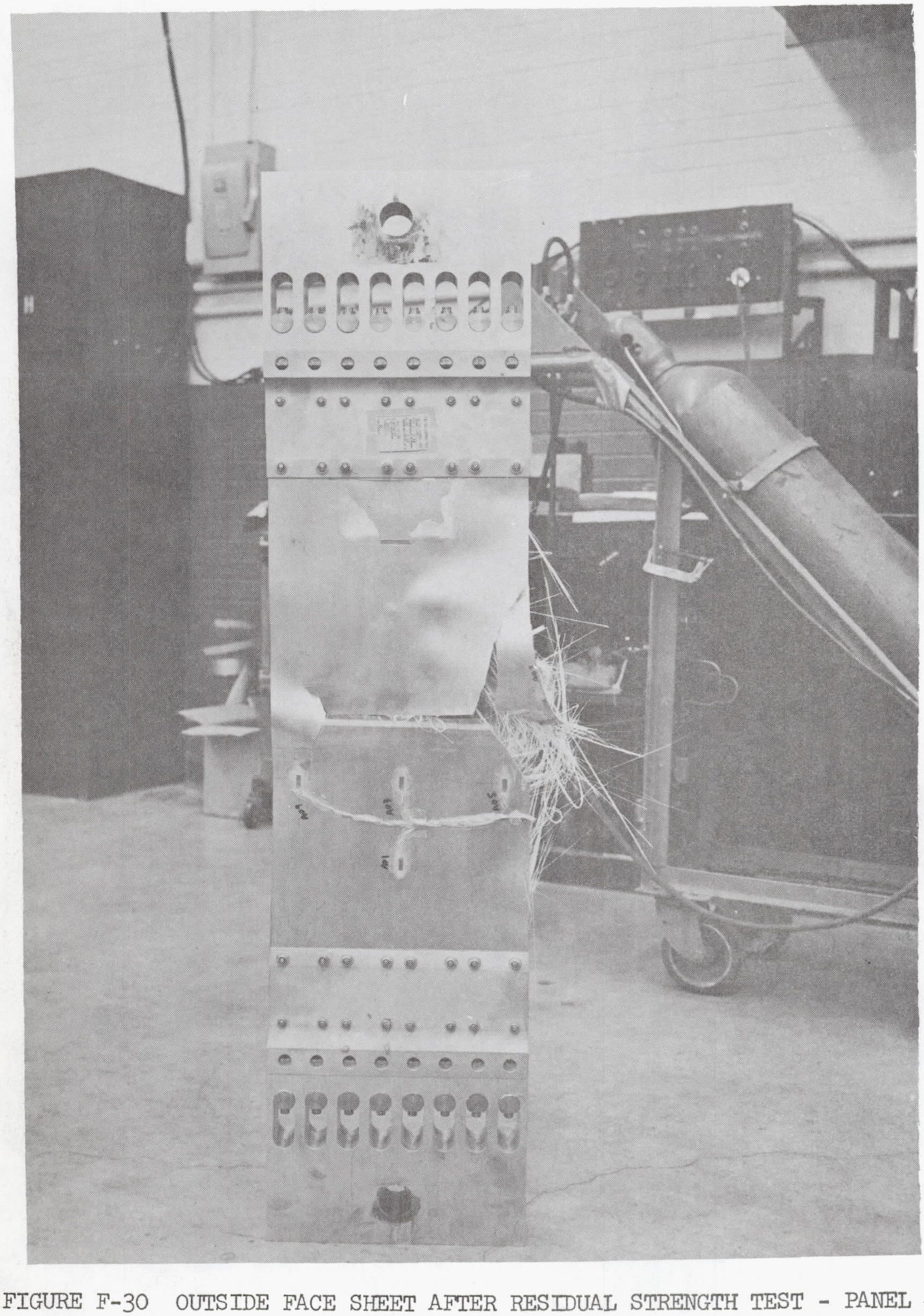

FIGURE F-30 OUTSIDE FACE SHEET AFTER RESIDUAL STRENGTH TEST - PANEL #8C

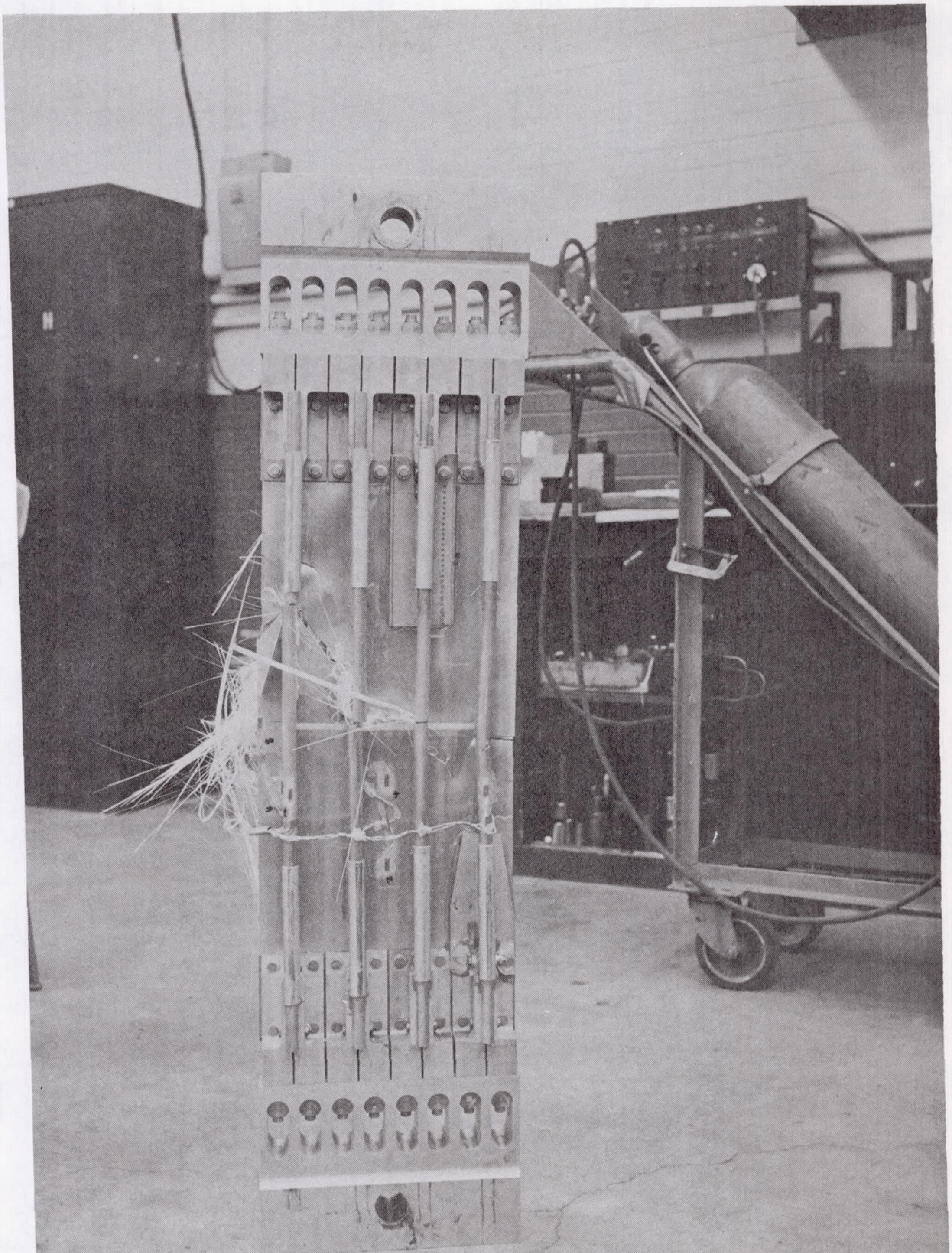

FIGURE F-31 INSIDE STIFFENER SHEET AFTER RESIDUAL STRENGTH TEST - PANEL #8C

Panel No. 8C		Primary Crack Lengths millimeters (inches)				Secondary Crack Lengths millimeters (inches)		
Cycle Rate	No. of Cycles	L/H Outside	R/H Outside	L/H Inside	R/H Inside			
4 Hz	20,000			3.2 (.125)	3.2 (.125)			
	21,000			3.8 (.15)	3.8 (.15)			
	21,700		5.1 (.20)					
	22,000			5.1 (.20)				
	22,200	3.2 (.125)						
	23,200	3.8 (.15)						
	23,900				5.1 (.20)			
	25,100		6.4 (.25)					
	25,700	5.1 (.20)						
	28,000			6.4 (.25)				
	29,500				6.4 (.25)			
	30,300	6.4 (.25)						
	32,960			7.6 (.30)				
	35,060				7.6 (.30)			
	35,860		7.6 (.30)					
	36,860	7.6 (.30)						
	39,060			8.9 (.35)				
	40,060		8.9 (.35)					
	40,460				8.9 (.35)			
	45,060	8.9 (.35)						
	45,360			10.2 (.40)				
	46,860				10.2 (.40)			
	47,560		10.2 (.40)					
	50,660			11.4 (.45)				
	51,360	10.2 (.40)						
	53,360				11.4 (.45)			
	57,360			12.7 (.50)				
	57,560		11.4 (.45)					
	59,360	11.4 (.45)						
	61,060				12.7 (.50)			
	61,560		12.7 (.50)					
4 Hz	61,840			14.0 (.55)				

Panel No. 8C		Primary Crack Lengths millimeters (inches)				Secondary Crack Lengths millimeters (inches)		
Cycle Rate	No. of Cycles	L/H Outside	R/H Outside	L/H Inside	R/H Inside			
4 Hz	64,820				14.0 (.55)			
	67,360	12.7 (.50)						
	68,670			15.2 (.60)				
	69,260		14.0 (.55)					
	70,760				15.2 (.60)			
	73,860			16.5 (.65)				
4 Hz	73,960	14.0 (.55)						
4.5 Hz	77,030		15.2 (.60)					
	77,060				16.5 (.65)			
	79,680			17.8 (.70)				
	81,360	15.2 (.60)						
	82,300				17.8 (.70)			
	83,310		16.5 (.65)					
	84,640			19.0 (.75)				
	88,110	16.5 (.65)						
4.5 Hz	88,360				19.0 (.75)			
4 Hz	92,730		17.8 (.70)					
	93,170			20.3 (.80)				
	96,130	17.8 (.70)						
	98,150				20.3 (.80)			
	101,830		19.0 (.75)					
	102,030			21.6 (.85)				
	104,730	19.0 (.75)						
	105,030				21.6 (.85)			
	109,180		20.3 (.80)					
	109,530			22.9 (.90)				
	112,730				22.9 (.90)			
	114,030	20.3 (.80)						
	117,130			24.1 (.95)				
	117,530		21.6 (.85)					
	119,830				24.1 (.95)			
4 Hz	122,930	21.6 (.85)						

Panel No. 8C		Primary Crack Lengths millimeters (inches)				Secondary Crack Lengths millimeters (inches)		
Cycle Rate	No. of Cycles	L/H Outside	R/H Outside	L/H Inside	R/H Inside			
4 Hz	126,830		22.9 (.90)					
	127,030			25.4 (1.00)				
	128,530				25.4 (1.00)			
	128,830	22.9 (.90)						
	134,630			26.7 (1.05)				
	135,030		24.1 (.95)					
	137,580				26.7 (1.05)			
4 Hz	137,730	24.1 (.95)						
5 Hz	141,498			27.9 (1.10)				
	143,398				27.9 (1.10)			
	143,478		25.4 (1.00)					
	144,078	25.4 (1.00)						
	148,898			29.2 (1.15)				
	150,088		26.7 (1.05)					
	150,298				29.2 (1.15)			
	153,068	26.7 (1.05)						
	154,698			30.5 (1.20)				
	157,028				30.5 (1.20)			
	157,148		27.9 (1.10)					
	159,838	27.9 (1.10)						
	161,508			31.8 (1.25)				
	165,088				31.8 (1.25)			
	165,928		29.2 (1.15)					
	167,278	29.2 (1.15)						
	167,768			33.0 (1.30)				
	173,728	30.5 (1.20)						
	173,978		30.5 (1.20)					
	174,088				33.0 (1.30)			
	174,578			34.3 (1.35)				
	179,079		31.8 (1.25)					
5 Hz	179,719	31.8 (1.25)						
4.5Hz	187,009				34.3 (1.35)			

Panel No. 8C		Primary Crack Lengths millimeters (inches)				Secondary Crack Lengths millimeters (inches)		
Cycle Rate	No. of Cycles	L/H Outside	R/H Outside	L/H Inside	R/H Inside			
4.5 Hz	187,229			35.6 (1.40)				
	188,159		33.0 (1.30)					
	188,349	33.0 (1.30)						
	196,339		34.3 (1.35)					
	197,699	34.3 (1.35)						
	205,799	35.6 (1.40)						
	205,999		35.6 (1.40)					
	206,499			36.8 (1.45)				
	208,199				36.8 (1.45)			
	213,599		36.8 (1.45)					
	215,099	36.8 (1.45)						
	217,199			38.1 (1.50)				
	219,499		38.1 (1.50)					
	220,129			39.4 (1.55)				
4.5 Hz	224,669	38.1 (1.50)						
4 Hz	229,129			40.6 (1.60)				
	229,219		39.4 (1.55)					
	233,499	39.4 (1.55)						
	234,919				38.1 (1.50)			
	235,919			41.9 (1.65)				
	240,099		40.6 (1.60)					
	240,499				39.4 (1.55)			
	241,799	40.6 (1.60)						
	243,999			43.2 (1.70)				
	245,649				40.6 (1.60)			
	249,829			44.4 (1.75)				
	249,919		41.9 (1.65)					
	253,999	41.9 (1.65)						
	254,969				41.9 (1.65)			
	256,199			45.7 (1.80)				
	257,699		43.2 (1.70)					
4 Hz	260,499	43.2 (1.70)						

Panel No. 8C		Primary Crack Lengths millimeters (inches)				Secondary Crack Lengths millimeters (inches)		
Cycle Rate	No. of Cycles	L/H Outside	R/H Outside	L/H Inside	R/H Inside			
4 Hz	262,479				43.2 (1.70)			
	264,499		44.4 (1.75)					
	266,969			47.0 (1.85)				
	271,089	44.4 (1.75)						
	274,749				44.4 (1.75)			
	278,029		45.7 (1.80)					
	278,649			48.3 (1.90)				
	281,049	45.7 (1.80)						
	283,869				45.7 (1.80)			
	284,729			49.5 (1.95)				
	287,059		47.0 (1.85)					
	294,159	47.0 (1.85)						
	294,349				47.0 (1.85)			
	294,519			50.8 (2.00)				
	296,599		48.3 (1.90)					
	299,609				48.3 (1.90)			
	299,729			52.1 (2.05)				
	303,519	48.3 (1.90)						
	307,479				49.5 (1.95)			
	308,519			53.3 (2.10)				
	309,419		49.5 (1.95)					
	312,449	49.5 (1.95)						
	316,079			54.6 (2.15)				
	316,399		50.8 (2.00)					
	317,019				50.8 (2.00)			
	322,689			55.9 (2.20)				
	325,659	50.8 (2.00)						
	325,899				52.1 (2.05)			
	327,249		52.1 (2.05)					
	330,029			57.2 (2.25)				
	332,589	52.1 (2.05)						
4 Hz	335,259		53.3 (2.10)					

Panel No. 8C		Primary Crack Lengths millimeters (inches)				Secondary Crack Lengths millimeters (inches)		
Cycle Rate	No. of Cycles	L/H Outside	R/H Outside	L/H Inside	R/H Inside			
4 Hz	336,609			58.4 (2.30)				
	336,829				53.3 (2.10)			
	342,109	53.3 (2.10)						
	342,809			59.7 (2.35)				
	345,759		54.6 (2.15)					
	346,349			61.0 (2.40)				
	348,369				54.6 (2.15)			
	350,549	54.6 (2.15)						
	350,859			62.2 (2.45)				
	353,369		55.9 (2.20)					
	356,769				55.9 (2.20)			
	358,179			63.5 (2.50)				
	360,679	55.9 (2.20)	57.2 (2.25)					
	364,339			64.8 (2.55)				
	369,609	57.2 (2.25)						
	369,619		58.4 (2.30)					
	369,949				57.2 (2.25)			
	370,389			66.0 (2.60)				
	376,189			67.3 (2.65)				
	377,489	58.4 (2.30)						
	377,839		59.7 (2.35)					
	378,109				58.4 (2.30)			
	387,481	59.7 (2.35)	61.0 (2.40)	68.6 (2.70)	59.7 (2.35)			
	391,625			69.8 (2.75)				
	394,365		62.2 (2.45)					
	394,595				61.0 (2.40)			
	396,315	61.0 (2.40)						
	396,095			71.1 (2.80)				
	400,195			72.4 (2.85)				
	402,165		63.5 (2.50)					
	403,465				62.2 (2.45)			
4 Hz	405,835			73.7 (2.90)				

Panel No. 8C		Primary Crack Lengths millimeters (inches)				Secondary Crack Lengths millimeters (inches)		
Cycle Rate	No. of Cycles	L/H Outside	R/H Outside	L/H Inside	R/H Inside			
4 Hz	406,555	62.2 (2.45)						
	412,905				63.5 (2.50)			
	412,985		64.8 (2.55)					
	413,175			74.9 (2.95)				
	413,225	63.5 (2.50)						
	420,475			76.2 (3.00)				
	421,835		66.0 (2.60)					
	422,385				64.8 (2.55)			
	427,685		67.3 (2.65)	77.5 (3.05)	67.3 (2.65)			
	443,210		68.6 (2.70)					
	443,235			78.7 (3.10)				
	443,240	67.3 (2.65)						
	443,285				68.6 (2.70)			
	446,085	68.6 (2.70)						
	446,885				69.8 (2.75)			
	448,185		69.8 (2.75)					
	451,485				71.1 (2.80)			
	452,785		71.1 (2.80)					
	460,685		72.4 (2.85)					
	460,885				72.4 (2.85)			
	462,185	69.8 (2.75)						
	463,585			82.6 (3.25)				
	464,385			83.8 (3.30)				
	465,985			85.1 (3.35)				
	466,685			87.6 (3.45)				
	467,685			88.9 (3.50)				
	468,585			90.2 (3.55)				
	468,685	71.1 (2.80)						
	469,285			91.4 (3.60)				
	470,485			92.7 (3.65)				
	471,185				73.7 (2.90)			
4 Hz	471,585			94.0 (3.70)				

Panel No. 8C		Primary Crack Lengths millimeters (inches)				Secondary Crack Lengths millimeters (inches)		
Cycle Rate	No. of Cycles	L/H Outside	R/H Outside	L/H Inside	R/H Inside			
4 Hz	471,685	72.4 (2.85)						
	472,585			95.2 (3.75)				
	474,485			96.5 (3.80)				
	474,685	73.7 (2.90)						
	475,285			97.8 (3.85)				
	475,685		73.7 (2.90)					
	476,885			99.1 (3.90)				
	477,685				74.9 (2.95)			
	479,185			100.3 (3.95)				
	480,485			101.6 (4.00)				
	481,685			102.9 (4.05)				
	482,485		74.9 (2.95)					
	482,685			104.1 (4.10)				
	483,685	74.9 (2.95)						
	483,925			105.4 (4.15)				
	485,585				76.2 (3.00)			
	486,185				77.5 (3.05)			
	487,065			106.7 (4.20)				
	487,585		76.2 (3.00)					
	489,585			108.0 (4.25)				
	492,185			109.2 (4.30)				
	493,585			110.5 (4.35)				
	495,285			111.8 (4.40)				
	496,585			113.0 (4.45)				
	497,685			114.3 (4.50)				
	498,585	76.2 (3.00)	77.5 (3.05)					
	502,285	77.5 (3.05)						
	502,485			115.6 (4.55)				
	503,785			116.8 (4.60)				
	505,135		78.7 (3.10)					
	506,385	78.7 (3.10)						
4 Hz	506,785			118.1 (4.65)				

Panel No. 8C		Primary Crack Lengths millimeters (inches)				Secondary Crack Lengths millimeters (inches)		
Cycle Rate	No. of Cycles	L/H Outside	R/H Outside	L/H Inside	R/H Inside			
4 Hz	508,885			119.4 (4.70)				
	511,685			120.6 (4.75)				
	512,885				78.7 (3.10)			
	515,135		80.0 (3.15)					
	519,585			121.9 (4.80)				
	520,785	80.0 (3.15)						
	521,285		81.3 (3.20)					
	522,826			123.2 (4.85)				
	524,926	81.3 (3.20)						
	526,426			124.5 (4.90)				
	526,626		82.6 (3.25)					
	527,426	82.6 (3.25)						
	529,826			125.7 (4.95)				
	532,826			127.0 (5.00)				
	534,226		83.8 (3.30)					
	534,526	83.8 (3.30)						
	535,826			128.3 (5.05)				
	542,650				82.6 (3.25)			
	542,760			129.5 (5.10)				
	543,170				83.8 (3.30)			
	544,610				85.1 (3.35)			
	545,370				86.4 (3.40)			
	545,470		85.1 (3.35)					
	545,570		86.4 (3.40)					
	548,370				87.6 (3.45)			
	548,770			130.8 (5.15)				
	550,270				88.9 (3.50)			
	551,470				90.2 (3.55)			
	551,670	85.1 (3.35)						
	552,670				91.4 (3.60)			
	553,770	86.4 (3.40)						
4 Hz	553,970				92.7 (3.65)			

Panel No. 8C		Primary Crack Lengths millimeters (inches)				Secondary Crack Lengths millimeters (inches)		
Cycle Rate	No. of Cycles	L/H Outside	R/H Outside	L/H Inside	R/H Inside			
4 Hz	554,170			132.1 (5.20)				
4 Hz	554,529	87.6 (3.45)						
FINAL CRACK LENGTHS		87.6 (3.45)	86.4 (3.40)	132.1 (5.20)	92.7 (3.65)			

RESIDUAL STRENGTH = 453,700 N (102,000 lbs.)

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PANEL #9C

MATERIALS: ALUMINUM - GLASS

ADHESIVE: AF 126

ALUMINUM STRESS: 103 MN/m^2 (15 ksi)

MAXIMUM FATIGUE LOAD: 74,730N (16,800 lbf)

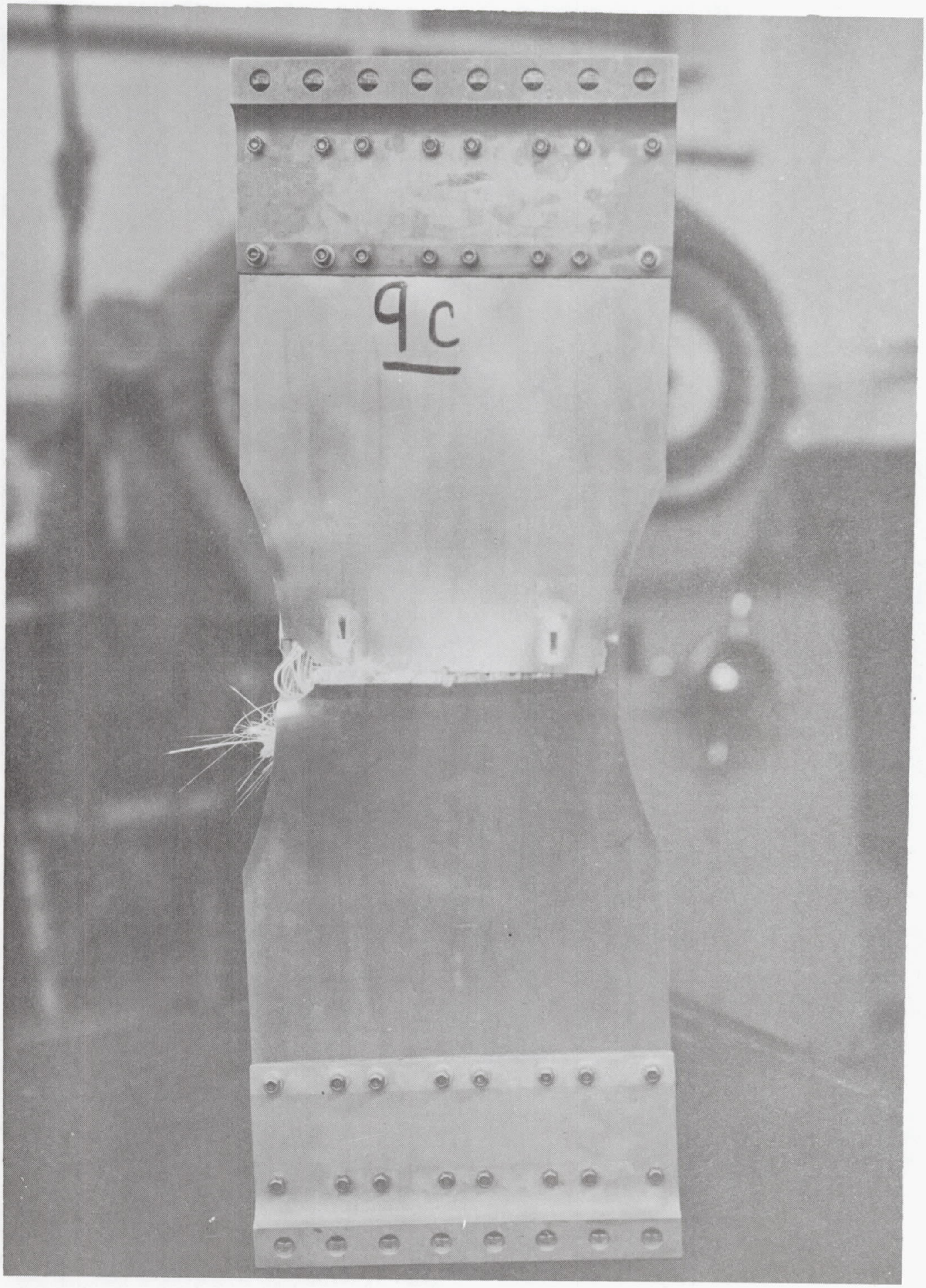

FIGURE F-32 OUTSIDE FACE SHEET AFTER RESIDUAL STRENGTH TEST - PANEL #9C

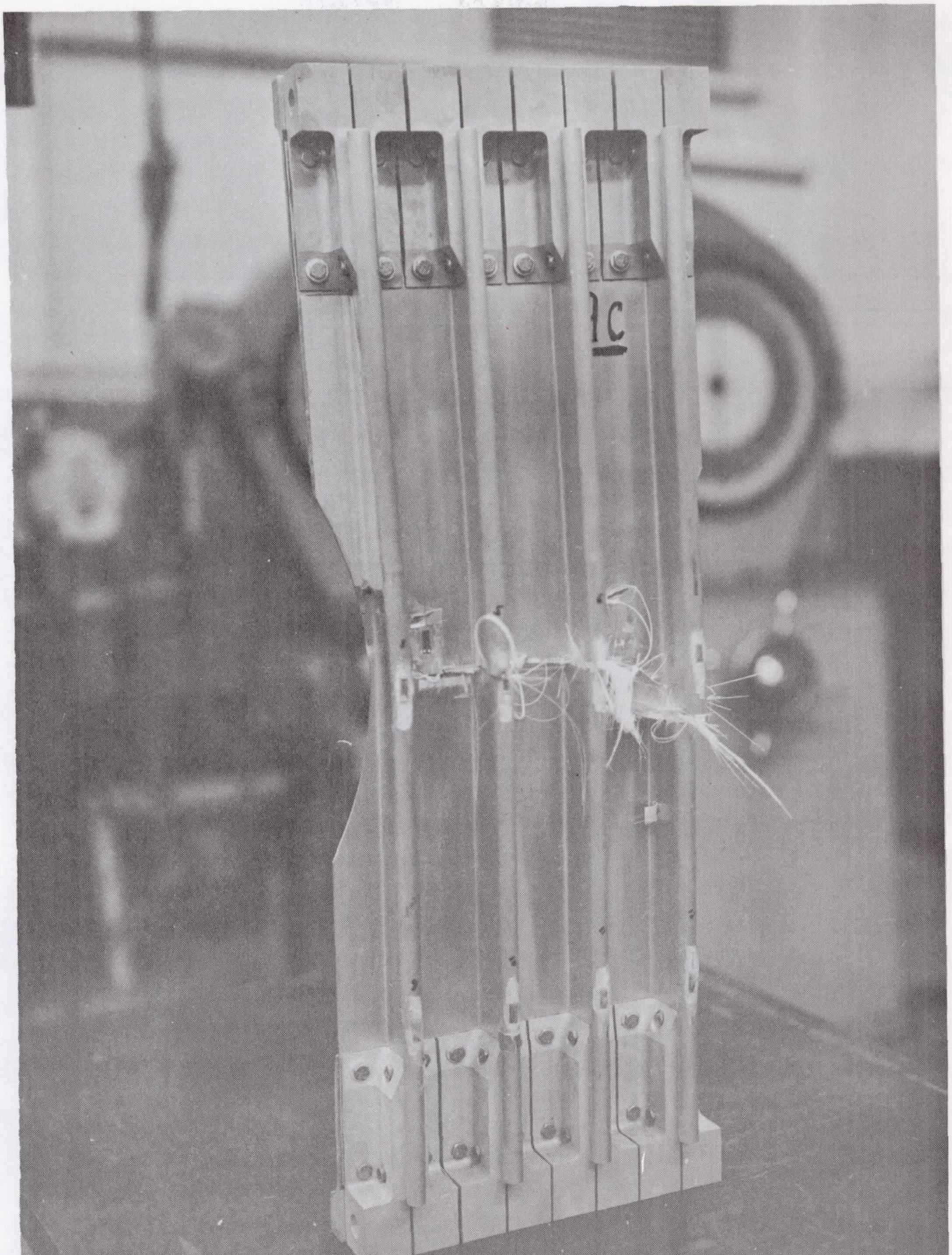

FIGURE F-33 INSIDE STIFFENER SHEET AFTER RESIDUAL STRENGTH TEST - PANEL #9C

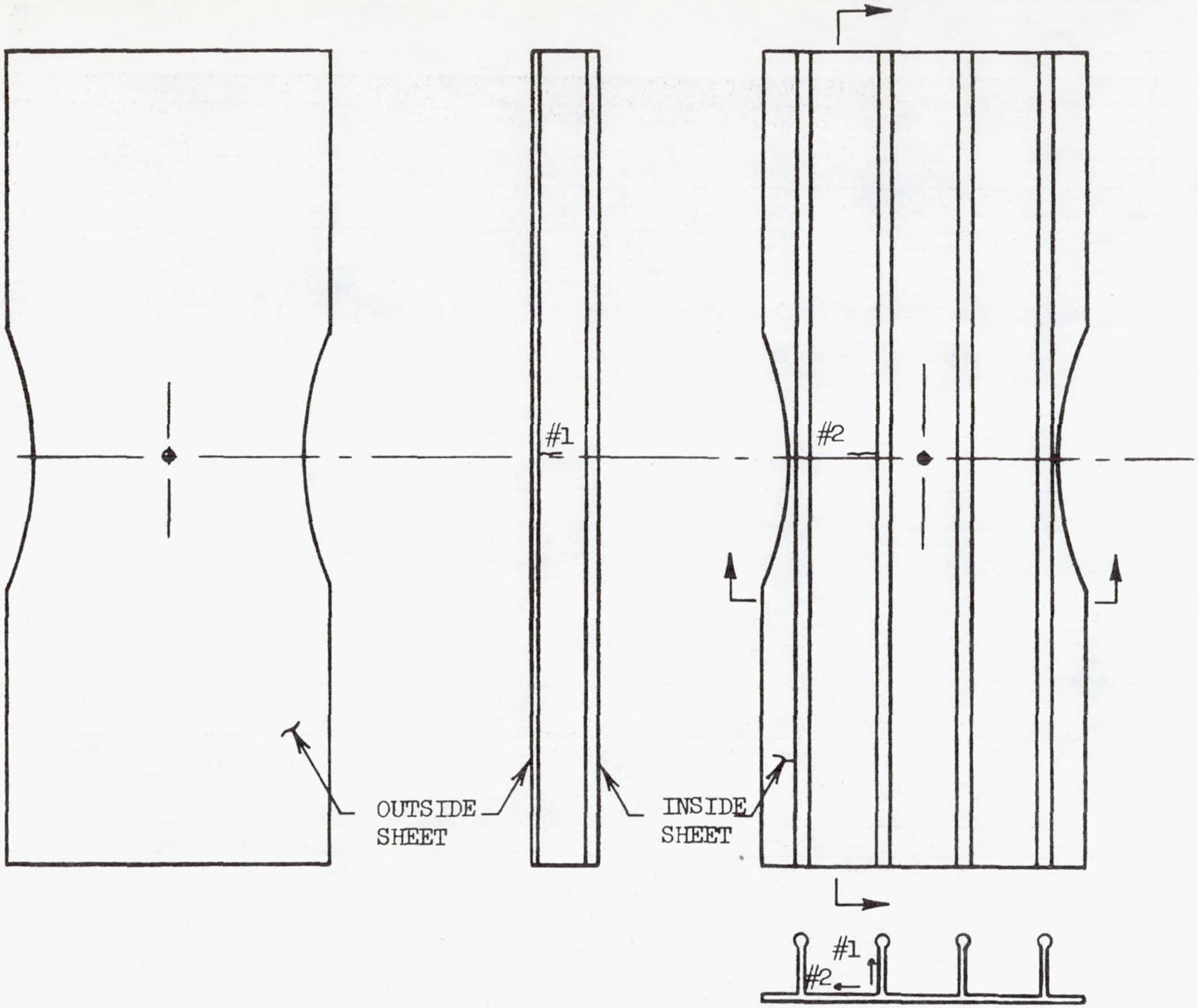

FIGURE F-34 SECONDARY CRACK LOCATIONS
ALUMINUM-GLASS PANEL #9C

Panel No. 9C		Primary Crack Lengths millimeters (inches)				Secondary Crack Lengths millimeters (inches)		
Cycle Rate	No. of Cycles	L/H Outside	R/H Outside	L/H Inside	R/H Inside			
10Hz	11,711							
4Hz	15,806		3.2 (.125)					
	21,711		5.1 (.20)					
	22,061	3.2 (.125)						
	24,031		6.4 (.25)					
	24,961	5.1 (.20)						
	29,991	6.4 (.25)	7.6 (.30)					
	34,711	7.6 (.30)	8.9 (.35)					
	37,111			3.2 (.125)	3.2 (.125)			
	40,011	8.9 (.35)						
	40,511		10.2 (.40)					
	42,211			5.1 (.20)	5.1 (.20)			
	45,311	10.2 (.40)	11.4 (.45)					
	50,571	11.4 (.45)	12.7 (.50)	6.4 (.25)	6.4 (.25)			
	56,191			7.6 (.30)	7.6 (.30)			
	56,291	12.7 (.50)	14.0 (..55)					
	61,791	14.0 (.55)						
	62,691			8.9 (.35)	8.9 (.35)			
	64, 591		15.2 (.60)					
	68, 191	15.2 (.60)						
	69,391				10.2 (.40)			
	70,691		16.5 (.65)					
	74,041	16.5 (.65)		10.2 (.40)				
	74,691		17.8 (.70)					
	77,991	17.8 (.70)			11.4 (.45)			
	79,191			11.4 (.45)				
	80,991		19.0 (.75)					
	83,391	19.0 (.75)						
	85,291				12.7 (.50)			
	86,391		20.3 (.80)					
	87,291			12.7 (.50)				
4Hz	88,191	20.3 (.80)						

Panel No. 9C		Primary Crack Lengths millimeters (inches)				Secondary Crack Lengths millimeters (inches)		
Cycle Rate	No. of Cycles	L/H Outside	R/H Outside	L/H Inside	R/H Inside			
4Hz	91,391		21.6 (.85)					
	91,791			14.0 (.55)				
	92,691				14.0 (.55)			
	94,691	21.6 (.85)						
	95,891		22.9 (.90)					
	98,691			15.2 (.60)	15.2 (.60)			
	100,691	22.9 (.90)						
	101,491		24.1 (.95)					
	102,291				16.5 (.65)			
	104,691	24.1 (.95)						
	105,691			16.5 (.65)				
	106,591		25.4 (1.00)					
	109,591		26.7 (1.05)					
	110,191			17.8 (.70)	17.8 (.70)			
	111,591	25.4 (1.00)						
	115,591		27.9 (1.10)					
	115,991			19.0 (.75)				
	117,691	26.7 (1.05)						
	118,091				19.0 (.75)			
	118,691		29.2 (1.15)					
	122,891			20.3 (.80)				
	124,291				20.3 (.80)			
	124,691	27.9 (1.10)	30.5 (1.20)					
	128,291			21.6 (.85)				
	128,591	29.2 (1.15)	31.8 (1.25)					
	129,291				21.6 (.85)			
	135,191	30.5 (1.20)	33.0 (1.30)					
	135,591			22.9 (.90)				
	135,891				22.9 (.90)			
	142,087	31.8 (1.25)	34.3 (1.35)	24.1 (.95)	24.1 (.95)			
	145,537				25.4 (1.00)			
4Hz	147,457			25.4 (1.00)				

Panel No. 9C		Primary Crack Lengths millimeters (inches)				Secondary Crack Lengths millimeters (inches)		
Cycle Rate	No. of Cycles	L/H Outside	R/H Outside	L/H Inside	R/H Inside			
4Hz	149,027		35.6 (1.40)					
	152,865	34.3 (1.35)						
	154,987		36.8 (1.45)	27.9 (1.10)	27.9 (1.10)			
	156,677	35.6 (1.40)						
	159,387			29.2 (1.15)	29.2 (1.15)			
	160,987		38.1 (1.50)					
	164,637	36.8 (1.45)						
	165,587			30.5 (1.20)	30.5 (1.20)			
	167,987		39.4 (1.55)					
4Hz	169,663	38.1 (1.50)		31.8 (1.25)	31.8 (1.25)			
5Hz	175,702				33.0 (1.30)			
	177,102			33.0 (1.30)				
5Hz	178,634		40.6 (1.60)					
10Hz	182,454	39.4 (1.55)						
	187,734				34.3 (1.35)			
	191,334			34.3 (1.35)				
	191,824		41.9 (1.65)					
	193,034	40.6 (1.60)						
	198,234				35.6 (1.40)			
	201,234			35.6 (1.40)				
	206,034		43.2 (1.70)					
	206,234	41.9 (1.65)						
	208,734				36.8 (1.45)			
	217,934	44.4 (1.75)						
	218,534			36.8 (1.45)				
	219,634				38.1 (1.50)			
	224,434			38.1 (1.50)				
	230,634		44.4 (1.75)					
	231,234			39.4 (1.55)				
	237,534		45.7 (1.80)					
	245,934	45.7 (1.80)						
10Hz	246,034				39.4 (1.55)			

Panel No. 9C		Primary Crack Lengths millimeters (inches)				Secondary Crack Lengths millimeters (inches)		
Cycle Rate	No. of Cycles	L/H Outside	R/H Outside	L/H Inside	R/H Inside			
10Hz	249,234			40.6 (1.60)				
	249,634		47.0 (1.85)					
	258,234			41.9 (1.65)	40.6 (1.60)			
	259,734	47.0 (1.85)						
	260,334		48.3 (1.90)					
	269,534	48.3 (1.90)						
	270,634		49.5 (1.95)					
	275,934			48.3 (1.90)				
	279,234		50.8 (2.00)					
	279,734	49.5 (1.95)						
	281,434				41.9 (1.65)			
	286,334			49.5 (1.95)				
	288,234		52.1 (2.05)					
	291,834	50.8 (2.00)						
	294,034			50.8 (2.00)				
	299,634			52.1 (2.05)				
	300,434				43.2 (1.70)			
	304,434		53.3 (2.10)					
	304,934	52.1 (2.05)						
	306,734			53.3 (2.10)				
	313,034		54.6 (2.15)					
	313,934				44.4 (1.75)			
	318,134			54.6 (2.15)				
	318,734	53.3 (2.10)	55.9 (2.20)					
	329,134	54.6 (2.15)	57.2 (2.25)					
	330,534			55.9 (2.20)				
	338,934			57.2 (2.25)				
	339,934		58.4 (2.30)					
	340,834	55.9 (2.20)						
	350,852		59.7 (2.35)					
	354,652			58.4 (2.30)	50.8 (2.00)			
10Hz	356,752	57.2 (2.25)						

Panel No. 9C		Primary Crack Lengths millimeters (inches)				Secondary Crack Lengths millimeters (inches)		
Cycle Rate	No. of Cycles	L/H Outside	R/H Outside	L/H Inside	R/H Inside			
10Hz	362,852				52.1 (2.05)			
	363,552			59.7 (2.35)				
	364,252		61.0 (2.40)					
	369,152			61.0 (2.40)				
	369.252	58.4 (2.30)						
	375,652		62.2 (2.45)					
	376,652				53.3 (2.10)			
	377,852			62.2 (2.45)				
	386,052	59.7 (2.35)						
	387,152		63.5 (2.50)					
	391,652			63.5 (2.50)				
	393,252		64.8 (2.55)					
	393,552				55.9 (2.20)			
	393,652	61.0 (2.40)						
	397,152			64.8 (2.55)				
	401,552		66.0 (2.60)					
	403,852				57.2 (2.25)			
	404,952			66.0 (2.60)				
	409,052	62.2 (2.45)						
	414,352			67.3 (2.65)				
	416,152		67.3 (2.65)					
	417,852	63.5 (2.50)						
	423,352			68.6 (2.70)				
	425,152				59.7 (2.35)			
	425,352		68.6 (2.70)					
	430,852	64.8 (2.55)						
	432,352			69.8 (2.75)				
	435,852				61.0 (2.40)			
	436,252		69.8 (2.75)					
	438,052		71.1 (2.80)					
	438,952	66.0 (2.60)						
10Hz	447,152		72.4 (2.85)					

Panel No. 9C		Primary Crack Lengths millimeters (inches)				Secondary Crack Lengths millimeters (inches)		
Cycle Rate	No. of Cycles	L/H Outside	R/H Outside	L/H Inside	R/H Inside			
10Hz	449,252				62.2 (2.45)			
	452,052			72.4 (2.85)				
	454,052	67.3 (2.65)						
	458,552		73.7 (2.90)					
	461,252				63.5 (2.50)			
	462,052			73.7 (2.90)				
	468,152	68.6 (2.70)						
	468,552				64.8 (2.55)			
	469,152		74.9 (2.95)					
	471,552			74.9 (2.95)				
	475,452				66.0 (2.60)			
	478,552		76.2 (3.00)					
	478,652	69.8 (2.75)						
	481,252			76.2 (3.00)				
	482,252				67.3 (2.65)			
	485,152				68.6 (2.70)			
	485,352		77.5 (3.05)					
	491,952	71.1 (2.80)						
	492,452		78.7 (3.10)					
	500,252		80.0 (3.15)					
	505,752	72.4 (2.85)						
	506,652		81.3 (3.20)					
	508,852				69.8 (2.75)			
	513,252		82.6 (3.25)					
	520,152	73.7 (2.90)						
	520,852		83.8 (3.30)					
	536,252		85.1 (3.35)					
	536,452	74.9 (2.95)						
	540,252				71.1 (2.80)			
	541,852		86.4 (3.40)					
	545,452	76.2 (3.00)						
10Hz	547,952				72.4 (2.85)			

Panel No. 9C		Primary Crack Lengths millimeters (inches)				Secondary Crack Lengths millimeters (inches)		
Cycle Rate	No. of Cycles	L/H Outside	R/H Outside	L/H Inside	R/H Inside	#1	#2	
10Hz	551,153		88.9 (3.50)		73.7 (2.90)			
4Hz	555,653	77.5 (3.05)	90.2 (3.55)					
	557,053				74.9 (2.95)			
	557,153			81.3 (3.20)				
	557,853			82.6 (3.25)				
	558,253			83.8 (3.30)	76.2 (3.00)			
	559,153			85.1 (3.35)				
	559,853			86.4 (3.40)				
	560,353	78.7 (3.10)						
	560,453			87.6 (3.45)				
	561,153			88.9 (3.50)				
	562,253				80.0 (3.15)			
	562,753		91.4 (3.60)	91.4 (3.60)				
	563,053				82.6 (3.25)			
	563,353				83.8 (3.30)			
	563,553			92.7 (3.65)				
	564,153				85.1 (3.35)	10.2 (.40)		
	564,653			94.0 (3.70)				
	565,353				86.4 (3.40)			
	565,453					11.4 (.45)		
	565,553				87.6 (3.45)			
	565,653			95.2 (3.75)				
	565,753						11.4 (.45)	
	566,353	80.0 (3.15)			88.9 (3.50)			
	566,653						12.7 (.50)	
	566,753			96.5 (3.80)				
	567,053				90.2 (3.55)			
	567,153					12.7 (.50)		
	567,753				91.4 (3.60)			
	567,953			97.8 (3.85)				
	568,853			99.1 (3.90)	92.7 (3.65)			
4Hz	569,253		92.7 (3.65)				14.0 (.55)	

Panel No. 9C		Primary Crack Lengths millimeters (inches)				Secondary Crack Lengths millimeters (inches)		
Cycle Rate	No. of Cycles	L/H Outside	R/H Outside	L/H Inside	R/H Inside	#1	#2	
4Hz	570,153			100.3 (3.95)				
	570,253					14.0 (.55)		
	570,453				94.0 (3.70)			
	570,953			101.6 (4.00)				
	571,253				95.2 (3.75)			
	571,653			102.9 (4.05)				
	572,253			104.1 (4.10)		15.2 (.60)		
	572,953			Joins		Joins L/H	15.2 (.60)	
	573,253			#1	97.8 (3.85)	Primary		
	573,653		94.0 (3.70)	Secondary		Crack		
	573,953	81.3 (3.20)		Crack				
	574,853				99.1 (3.90)			
	576,653						16.5 (.65)	
4Hz	576,953				101.6 (4.00)			
5Hz	577,739				102.9 (4.05)			
	579,239				104.1 (4.10)			
	579,439						17.8 (.70)	
	580,439				105.4 (4.15)			
	581,239				106.7 (4.20)			
	582,139				108.0 (4.25)			
	582,939						19.0 (.75)	
	583,939				109.2 (4.30)			
	584,939		95.2 (3.75)					
	585,039				110.5 (4.35)			
	585,639	82.6 (3.25)						
	586,439				111.8 (4.40)			
	586,939						20.3 (.80)	
	587,739		96.5 (3.80)					
	588,439				114.3 (4.50)			
	590,439	83.8 (3.30)						
	591,039				115.6 (4.55)			
5Hz	591,539		97.8 (3.85)	104.1 (4.10)		15.2 (.60)		

Panel No. 9C		Primary Crack Lengths millimeters (inches)				Secondary Crack Lengths millimeters (inches)		
Cycle Rate	No. of Cycles	L/H Outside	R/H Outside	L/H Inside	R/H Inside	#1	#2	
5Hz	592,339			104.1 (4.10)		15.2 (.60)	21.6 (.85)	
	593,139				116.8 (4.60)			
	594,839	85.1 (3.35)						
	595,139				118.1 (4.65)			
	596,239						22.9 (.90)	
	597,239		99.1 (3.90)					
	599,239				119.4 (4.70)			
	600,439						24.1 (.95)	
	601,339	86.4 (3.40)						
	601,439				120.6 (4.75)			
	601,939		100.3 (3.95)					
	603,139				121.9 (4.80)			
	604,039						25.4 (1.00)	
	606,539				123.2 (4.85)			
	607,139						26.7 (1.05)	
	609,639				124.5 (4.90)			
	610,739		101.6 (4.00)					
	610,939						27.9 (1.10)	
	611,139	87.6 (3.45)						
	614,039				125.7 (4.95)			
	616,439						29.2 (1.15)	
	617,139	88.9 (3.50)	102.9 (4.05)					
	617,339				127.0 (5.00)			
	620,139						30.5 (1.20)	
	620,639				128.3 (5.05)			
	620,939		104.1 (4.10)					
	621,139	90.2 (3.55)						
	624,139				129.5 (5.10)			
	624,339						31.8 (1.25)	
	624,839		105.4 (4.15)					
	625,139	91.4 (3.60)						
5Hz	628,039			104.1 (4.10)	130.8 (5.15)	15.2 (.60)		

Panel No. 9C		Primary Crack Lengths millimeters (inches)				Secondary Crack Lengths millimeters (inches)		
Cycle Rate	No. of Cycles	L/H Outside	R/H Outside	L/H Inside	R/H Inside	#1	#2	
5 Hz	628,439		106.7 (4.20)	104.1 (4.10)		15.2 (.60)		
	628,539	92.7 (3.65)						
	628,939						33.0 (1.30)	
5 Hz	631,049			104.1 (4.10)	132.1 (5.20)	15.2 (.60)		
FINAL CRACK LENGTH		92.7 (3.65)	106.7 (4.20)	104.1 (4.10)	132.1 (5.20)	15.2 (.60)	33.0 (1.30)	
RESIDUAL STRENGTH = 286,900N (64,500 lbs)								

PANEL #10C

MATERIALS: ALUMINUM - GLASS

ADHESIVE: AF 126

ALUMINUM STRESS: 138 MN/m^2 (20 ksi)

MAXIMUM FATIGUE LOAD: 100,080N (22,500 lbf)

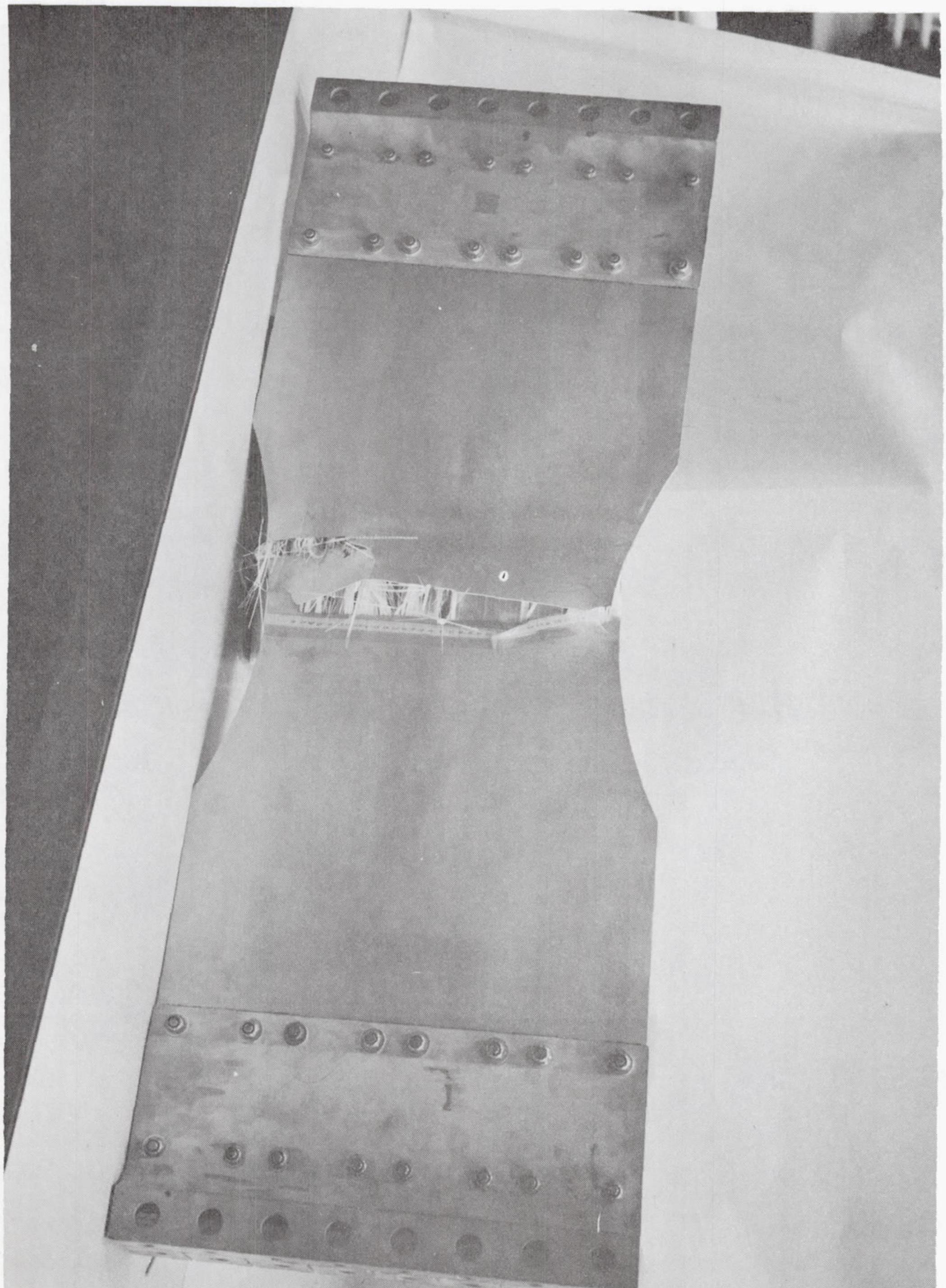

FIGURE F-35 OUTSIDE FACE SHEET AFTER RESIDUAL STRENGTH TEST - PANEL #10C

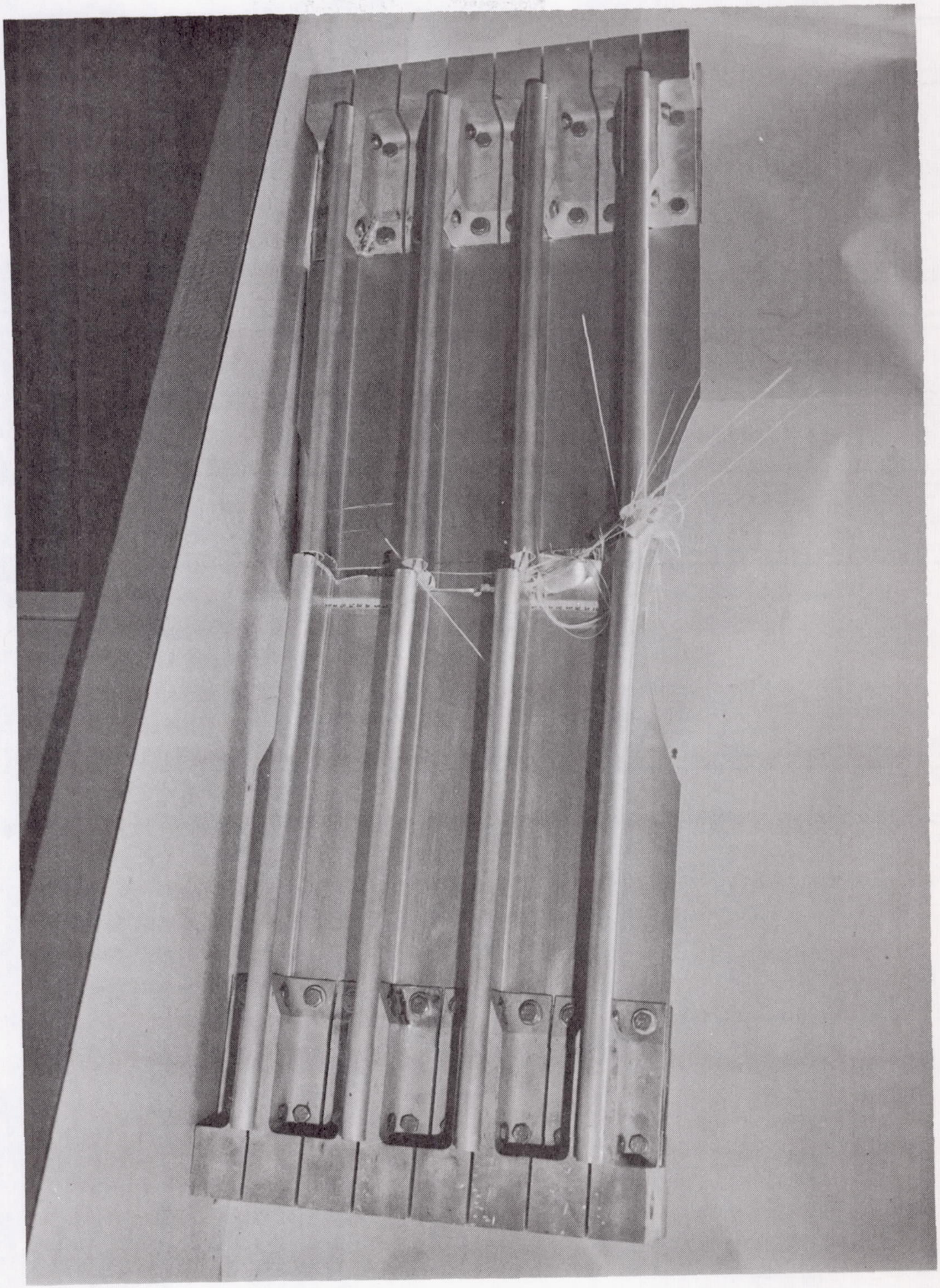

FIGURE F-36 INSIDE STIFFENER SHEET AFTER RESIDUAL STRENGTH TEST - PANEL #10C

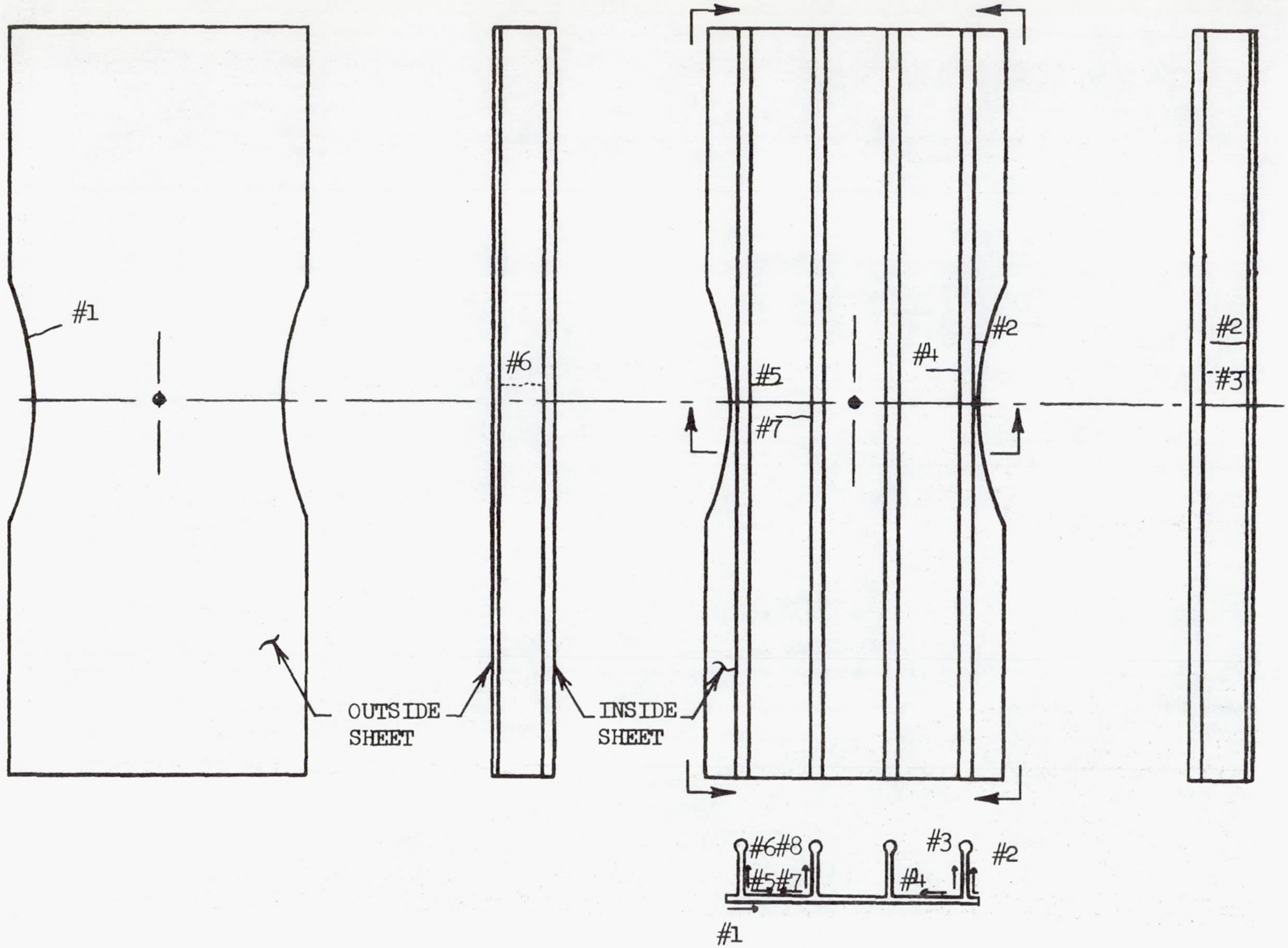

FIGURE F-37 SECONDARY CRACK LOCATIONS
ALUMINUM-GLASS PANEL #10C

Panel No. 10C		Primary Crack Lengths millimeters (inches)				Secondary Crack Lengths millimeters (inches)		
Cycle Rate	No. of Cycles	L/H Outside	R/H Outside	L/H Inside	R/H Inside			
5.5Hz	10,800		3.2 (.125)					
	12,000	3.2 (.125)						
	12,600		5.1 (.20)					
	15,700	5.1 (.20)						
	15,900		6.4 (.25)					
	16,000				3.2 (.125)			
	16,300			3.2 (.125)				
5.5Hz	18,800				5.1 (.20)			
10Hz	22,000		7.6 (.30)					
	22,300	6.4 (.25)						
	22,800			5.1 (.20)				
	25,100				6.4 (.25)			
	27,500	7.6 (.30)						
	28,000			6.4 (.25)				
	28,700		8.9 (.35)					
	30,000				7.6 (.30)			
	32,300	8.9 (.35)						
	33,900		10.2 (.40)					
	34,400			7.6 (.30)				
	35,100				8.9 (.35)			
	40,400				10.2 (.40)			
	40,700			8.9 (.35)				
	41,500	10.2 (.40)	11.4 (.45)					
	46,100	11.4 (.45)						
	46,500		12.7 (.50)					
	47,200			10.2 (.40)	11.4 (.45)			
	50,100	12.7 (.50)						
	51,400				12.7 (.50)			
	53,100		14.0 (.55)					
	56,100	14.0 (.55)						
	56,200			11.4 (.45)				
10Hz	58,200		15.2 (.60)					

Panel No. 10C		Primary Crack Lengths millimeters (inches)				Secondary Crack Lengths millimeters (inches)		
Cycle Rate	No. of Cycles	L/H Outside	R/H Outside	L/H Inside	R/H Inside			
10Hz	59,600				14.0 (.55)			
	61,400			12.7 (.50)				
	61,700	15.2 (.60)						
	64,400				15.2 (.60)			
	65,100		16.5 (.65)					
	67,000			14.0 (.55)				
	68,500	16.5 (.65)						
	70,800				16.5 (.65)			
	71,100		17.8 (.70)					
	74,200			15.2 (.60)				
	74,800	17.8 (.70)						
	76,500		19.0 (.75)					
	77,000				17.8 (.70)			
	80,800			16.5 (.65)				
	80,900	19.0 (.75)						
	82,400				19.0 (.75)			
	85,900		20.3 (.80)					
	86,100	20.3 (.80)						
	87,200			17.8 (.70)				
	88,400		21.6 (.85)					
	88,800				20.3 (.80)			
	94,100			19.0 (.75)				
	94,200		22.9 (.90)					
	94,500	21.6 (.85)						
	94,900				21.6 (.85)			
	100,200			20.3 (.80)				
	100,400	22.9 (.90)						
	100,800		24.1 (.95)					
	101,000				22.9 (.90)			
	106,000			21.6 (.85)				
	106,400	24.1 (.95)	25.4 (1.00)					
10Hz	107,400				24.1 (.95)			

Panel No. 10C		Primary Crack Lengths millimeters (inches)				Secondary Crack Lengths millimeters (inches)		
Cycle Rate	No. of Cycles	L/H Outside	R/H Outside	L/H Inside	R/H Inside			
10Hz	112,200	25.4 (1.00)						
	112,300		26.7 (1.05)					
	112,600			22.9 (.90)				
	113,400				25.4 (1.00)			
	117,600	26.7 (1.05)						
	118,700			24.1 (.95)				
	119,000				26.7 (1.05)			
	120,700	27.9 (1.10)	27.9 (1.10)					
	124,100		29.2 (1.15)					
	125,200			25.4 (1.00)				
	125,500				27.9 (1.10)			
	126,900	29.2 (1.15)						
	131,400			26.7 (1.05)				
	131,800				29.2 (1.15)			
	132,200		30.5 (1.20)					
	136,300	30.5 (1.20)						
	137,000			27.9 (1.10)				
	137,500				30.5 (1.20)			
	140,600	31.8 (1.25)	31.8 (1.25)					
	143,100			29.2 (1.15)				
	143,700				31.8 (1.25)			
	143,900		33.0 (1.30)					
	147,800	33.0 (1.30)						
	148,000			30.5 (1.20)				
	149,700		34.3 (1.35)					
	150,000				33.0 (1.30)			
	154,100			31.8 (1.25)				
	154,700	34.3 (1.35)						
	156,100				34.3 (1.35)			
	158,653			33.0 (1.30)				
	160,143	35.6 (1.40)						
10Hz	160,453		35.6 (1.40)					

Panel No. 10C		Primary Crack Lengths millimeters (inches)				Secondary Crack Lengths millimeters (inches)		
Cycle Rate	No. of Cycles	L/H Outside	R/H Outside	L/H Inside	R/H Inside			
10Hz	162,253				35.6 (1.40)			
	163,053			34.3 (1.45)				
	165,053	36.8 (1.45)	36.8 (1.45)					
	170,303		38.1 (1.50)					
	170,653	38.1 (1.50)						
	170,753			35.6 (1.40)				
	176,953	39.4 (1.55)						
	177,753		39.4 (1.55)					
	178,453			38.1 (1.50)	40.6 (1.60)			
	178,853	40.6 (1.60)	40.6 (1.60)					
	182,753	41.9 (1.65)						
	186,553		41.9 (1.65)					
	188,953	43.2 (1.70)						
	190,353			39.4 (1.55)				
	194,153		43.2 (1.70)					
	194,653	44.4 (1.75)						
10 Hz	196,353			40.6 (1.60)				
8Hz	199,403				41.9 (1.65)			
8Hz	204,603			41.9 (1.65)	43.2 (1.70)			
8Hz	207,309	47.0 (1.85)	45.7 (1.80)	43.2 (1.70)	44.4 (1.75)			
10Hz	213,709			44.4 (1.75)				
	214,309		47.0 (1.85)					
	216,309	50.8 (2.00)			45.7 (1.80)			
	218,309		49.5 (1.95)	45.7 (1.80)				
	219,409				47.0 (1.85)			
	220,309	52.1 (2.05)						
	223,309		50.8 (2.00)	47.0 (1.85)	48.3 (1.90)			
	224,309	53.3 (2.10)						
	225,309		52.1 (2.05)					
	226,209			48.3 (1.90)	49.5 (1.95)			
	227,909	54.6 (2.15)						
10Hz	229,209		53.3 (2.10)					

Panel No. 10C		Primary Crack Lengths millimeters (inches)				Secondary Crack Lengths millimeters (inches)		
Cycle Rate	No. of Cycles	L/H Outside	R/H Outside	L/H Inside	R/H Inside			
10Hz	231,109				50.8 (2.00)			
	233,809		54.6 (2.15)					
	234,509	55.9 (2.20)						
	234,609			49.5 (1.95)				
	236,609				52.1 (2.05)			
	237,309	57.2 (2.25)						
	238,009		55.9 (2.20)					
	238,809			50.8 (2.00)				
	240,309		57.2 (2.25)					
	240,409				53.3 (2.10)			
	240,709	58.4 (2.30)						
	244,409		58.4 (2.30)					
	244,709			52.1 (2.05)				
	244,909	59.7 (2.35)						
	245,309				54.6 (2.15)			
	247,909			53.3 (2.10)				
	248,109		59.7 (2.35)					
	248,909	61.0 (2.40)						
	249,109				55.9 (2.20)			
	251,609			54.6 (2.15)				
	251,909		61.0 (2.40)					
	252,309	62.2 (2.45)						
	252,909				57.2 (2.25)			
	254,109	63.5 (2.50)						
	255,809		62.2 (2.45)					
	256,409			55.9 (2.20)				
	258,209				58.4 (2.30)			
	258,409	64.8 (2.55)						
	259,809		63.5 (2.50)					
	260,509	66.0 (2.60)						
	260,909			57.2 (2.25)				
10Hz	262,109				59.7 (2.35)			

Panel No. 10C		Primary Crack Lengths millimeters (inches)				Secondary Crack Lengths millimeters (inches)		
Cycle Rate	No. of Cycles	L/H Outside	R/H Outside	L/H Inside	R/H Inside	#1	#2	#3
10Hz	263,809			58.4 (2.30)				
	264,909		64.8 (2.55)					
	266,209				61.0 (2.40)			
	266,609	67.3 (2.65)						
	267,709			59.7 (2.35)				
	268,109		66.0 (2.60)					
	269,209	68.6 (2.70)						
	269,509		67.3 (2.65)					
	269,909				62.2 (2.45)			
	271,009	69.8 (2.75)						
10Hz	273,009			61.0 (2.40)				
5Hz	273,189					29.2 (1.15)	25.4 (1.00)	35.6 (1.40)
	274,109		68.6 (2.70)					
	274,409	71.1 (2.80)						
	275,909				63.5 (2.50)			
	276,609			62.2 (2.45)				
	278,009		69.8 (2.75)					
	280,009							
	280,309			63.5 (2.50)				
	280,709				64.8 (2.55)			
	281,709	72.4 (2.85)	71.1 (2.80)			31.8 (1.25)	27.9 (1.10)	
	282,109	73.7 (2.90)						
	283,709			64.8 (2.55)				
	284,109				66.0 (2.60)			
	284,409	74.9 (2.95)						
	284,809		72.4 (2.85)					
	285,309							
	287,309							38.1 (1.50)
	287,609	76.2 (3.00)	73.7 (2.90)					
	287,809			66.0 (2.60)				
	289,609					34.3 (1.35)		
5Hz	289,709				67.3 (2.65)			

Panel No. 10C		Secondary Crack Lengths millimeters (inches)						
Cycle Rate	No. of Cycles	#4	#5	#6				
10Hz	263,809							
	264,909							
	266,209							
	266,609							
	267,709							
	268,109							
	269,209							
	269,509							
	269,909							
	271,009							
10Hz	273,009							
5Hz	273,189	35.6 (1.40)	40.6 (1.60)	41.9 (1.65)				
	274,109			Crack				
	274,409			Stopped				
	275,909			in Bulb				
	276,609			Radius				
	278,009							
	280,009	38.1 (1.50)						
	280,309							
	280,709							
	281,709		43.2 (1.70)					
	282,109							
	283,709							
	284,109							
	284,409							
	284,809							
	285,309	40.6 (1.60)						
	287,309							
	287,609							
	287,809							
	289,609							
5Hz	289,709			41.9 (1.65)				

Panel No. 10C		Primary Crack Lengths millimeters (inches)				Secondary Crack Lengths millimeters (inches)		
Cycle Rate	No. of Cycles	L/H Outside	R/H Outside	L/H Inside	R/H Inside	#1	#2	#3
5Hz	289,809		74.9 (2.95)					
	290,109						30.5 (1.20)	
	290,209							
	290,309							
	292,009	77.5 (3.05)						
	292,209			67.3 (2.65)				
	294,209		76.2 (3.00)					
	294,909				68.6 (2.70)			
	296,509			68.6 (2.70)				
	296,709		77.5 (3.05)					
	296,909					36.8 (1.45)		40.6 (1.60)
	297,309						33.0 (1.30)	
	299,309	78.7 (3.10)			69.8 (2.75)			
	300,009		78.7 (3.10)					
	300,309							41.9 (1.65)
	301,309	80.0 (3.15)	80.0 (3.15)					Crack
	301,909			69.8 (2.75)				Stopped
	303,409							in Bulb
	303,709	81.3 (3.20)						Radius
	304,109				71.1 (2.80)			
	304,309		81.3 (3.20)					
	304,609	←Overlaps #1				39.4 (1.55)		
	305,309	Secondary				Overlaps L/H		
	307,009	Crack		71.1 (2.80)		Primary		
	307,309	82.6 (3.25)				Crack		
	307,509		82.6 (3.25)					
	309,309							
	309,909				72.4 (2.85)			
	310,209		83.8 (3.30)					
	310,709	83.8 (3.30)						
	311,309					41.9 (1.65)	35.6 (1.40)	
5Hz	311,509			72.4 (2.85)				41.9 (1.65)

Panel No. 10C		Secondary Crack Lengths millimeters (inches)						
Cycle Rate	No. of Cycles	#4	#5	#6				
5Hz	289,809			41.9 (1.65)				
	290,109							
	290,209	43.2 (1.70)						
	290,309		45.7 (1.80)					
	292,009							
	292,209							
	294,209							
	294,909							
	296,509							
	296,709							
	296,909		48.3 (1.90)					
	297,309							
	299,309	45.7 (1.80)						
	300,009							
	300,309							
	301,309							
	301,909							
	303,409		50.8 (2.00)					
	303,709							
	304,109							
	304,309							
	304,609							
	305,309	48.3 (1.90)						
	307,009							
	307,309							
	307,509							
	309,309		53.3 (2.10)					
	309,909							
	310,209							
	310,709							
	311,309							
5Hz	311,509			41.9 (1.65)				

Panel No. 10C		Primary Crack Lengths millimeters (inches)				Secondary Crack Lengths millimeters (inches)		
Cycle Rate	No. of Cycles	L/H Outside	R/H Outside	L/H Inside	R/H Inside	#1	#2	#3
5Hz	312,409							41.9 (1.65)
	312,609							
	315,309				73.7 (2.90)			
	315,709							
	316,109	86.4 (3.40)	86.4 (3.40)					
	316,309							
	316,809							
	317,309					44.4 (1.75)		
	317,809							
	317,909		87.6 (3.45)					
	318,009				81.3 (3.20)			
	318,109			81.3 (3.20)				
	318,309				82.6 (3.25)			
	318,509			82.6 (3.25)				
	318,609	87.6 (3.45)						
	318,709				83.8 (3.30)			
	318,909			83.8 (3.30)				
	319,009				85.1 (3.35)			
	319,209				86.4 (3.40)			
	319,309			85.1 (3.35)				
	319,709			86.4 (3.40)	87.6 (3.45)			
	320,209			87.6 (3.45)	88.9 (3.50)			
	320,509				90.2 (3.55)			
	320,609			88.9 (3.50)				
	320,709		88.9 (3.50)					
	321,009						38.1 (1.50)	
	321,109			90.2 (3.55)	91.4 (3.60)			
	321,409				92.7 (3.65)			
	321,609			91.4 (3.60)				
	322,009				94.0 (3.70)			
	322,309			92.7 (3.65)				
5Hz	322,509				95.2 (3.75)			41.9 (1.65)

Panel No. 10C		Secondary Crack Lengths millimeters (inches)						
Cycle Rate	No. of Cycles	#4	#5	#6	#7	#8		
5Hz	312,409			41.9 (1.65)		10.2 (.40)		
	312,609	50.8 (2.00)						
	315,309							
	315,709		55.9 (2.20)					
	316,109							
	316,309				6.4 (.25)			
	316,809					11.4 (.45)		
	317,309							
	317,809				7.6 (.30)			
	317,909							
	318,009							
	318,109							
	318,309							
	318,509							
	318,609							
	318,709							
	318,909							
	319,009	53.3 (2.10)						
	319,209							
	319,309							
	319,709							
	320,209							
	320,509							
	320,609							
	320,709							
	321,009							
	321,109							
	321,409							
	321,609							
	322,009							
	322,309							
5Hz	322,509			41.9 (1.65)				

Panel No. 10C		Primary Crack Lengths millimeters (inches)				Secondary Crack Lengths millimeters (inches)		
Cycle Rate	No. of Cycles	L/H Outside	R/H Outside	L/H Inside	R/H Inside	#1	#2	#3
5Hz	322,709	88.9 (3.50)						41.9 (1.65)
	322,909			94.0 (3.70)				
	323,009				96.5 (3.80)			
	323,083			95.2 (3.75)		47.0 (1.85)		
	324,083			96.5 (3.80)				
	324,983			97.8 (3.85)				
	325,083							
	325,183				97.8 (3.85)			
	325,583	90.2 (3.55)						
	325,683			99.1 (3.90)				
	326,333		91.4 (3.60)					
	326,383				100.3 (3.95)			
	326,783			101.6 (4.00)	101.6 (4.00)			
	327,083			102.9 (4.05)				
	327,273		92.7 (3.65)	Overlaps #8				
	327,283			Secondary	102.9 (4.05)			
	327,683	91.4 (3.60)		Crack				
	327,583			104.1 (4.10)				
	327,883				104.1 (4.10)			
	328,183			105.4 (4.15)				
	328,383							
	328,683							
	328,883				105.4 (4.15)			
	329,083		94.0 (3.70)					
	329,383				106.7 (4.20)			
	329,583							
	330,183	92.7 (3.65)						
	330,383			106.7 (4.20)	108.0 (4.25)			
	330,483					49.5 (1.95)		
	331,483							
	331,683				109.2 (4.30)			
5Hz	332,483				110.5 (4.35)			41.9 (1.65)

Panel No. 10C		Secondary Crack Lengths millimeters (inches)						
Cycle Rate	No. of Cycles	#4	#5	#6	#7	#8		
5Hz	322,709			41.9 (1.65)				
	322,909							
	323,009							
	323,083	55.9 (2.20)			12.7 (.50)			
	324,083							
	324,983							
	325,083		61.0 (2.40)		Overlaps			
	325,183		Overlaps		#5			
	325,583		#7		Secondary			
	325,683		Secondary		Crack			
	326,333		Crack					
	326,383							
	326,783							
	327,083					Overlaps		
	327,273					L/H Primary		
	327,283					Crack		
	327,683							
	327,583							
	327,883							
	328,183							
	328,383				14.0 (.55)			
	328,683					17.8 (.70)		
	328,883							
	329,083							
	329,383							
	329,583		63.5 (2.50)					
	330,183							
	330,383	58.4 (2.30)						
	330,483							
	331,483				15.2 (.60)	20.3 (.80)		
	331,683							
5Hz	332,483			41.9 (1.65)				

Panel No. 10C		Primary Crack Lengths millimeters (inches)				Secondary Crack Lengths millimeters (inches)		
Cycle Rate	No. of Cycles	L/H Outside	R/H Outside	L/H Inside	R/H Inside	#1	#2	#3
5Hz	332,683		95.2 (3.75)					41.9 (1.65)
	333,283				111.8 (4.40)			
	333,483			108.0 (4.25)				
	333,783		96.5 (3.80)					
	334,283				113.0 (4.45)			
	334,383	94.0 (3.70)						
	334,583			109.2 (4.30)	114.3 (4.50)			
	335,183		97.8 (3.85)					
	335,883	95.2 (3.75)						
	336,083				118.1 (4.65)			
	336,383			110.5 (4.35)				
	337,283		99.1 (3.90)					
	338,583	96.5 (3.80)			119.4 (4.70)			
	338,883		100.3 (3.95)					
	340,083			111.8 (4.40)				
	340,583		101.6 (4.00)					
	341,183				120.6 (4.75)			
5Hz	341,983	97.8 (3.85)	102.9 (4.05)					41.9 (1.65)
FINAL CRACK LENGTH		97.8 (3.85)	102.9 (4.05)	111.8 (4.40)	120.6 (4.75)	49.5 (1.95)	31.8 (1.50)	41.9 (1.65
	RESIDUAL STRENGTH =		276,900 N	(62,250 lbs)				

Panel No. 10C		Secondary Crack Lengths millimeters (inches)						
Cycle Rate	No. of Cycles	#4	#5	#6	#7	#8		
5Hz	332,683			41.9 (1.65)				
	333,283							
	333,483							
	333,783							
	334,283							
	334,383							
	334,583							
	335,183							
	335,883							
	336,083							
	336,283							
	337,283							
	338,583							
	338,883							
	340,083							
	340,583							
	341,183							
5Hz	341,983			41.9 (1.65)				
FINAL CRACK LENGTHS		58.4 (2.30)	63.5 (2.50)	41.9 (1.65)	15.2 (.60)	20.3 (.80)		

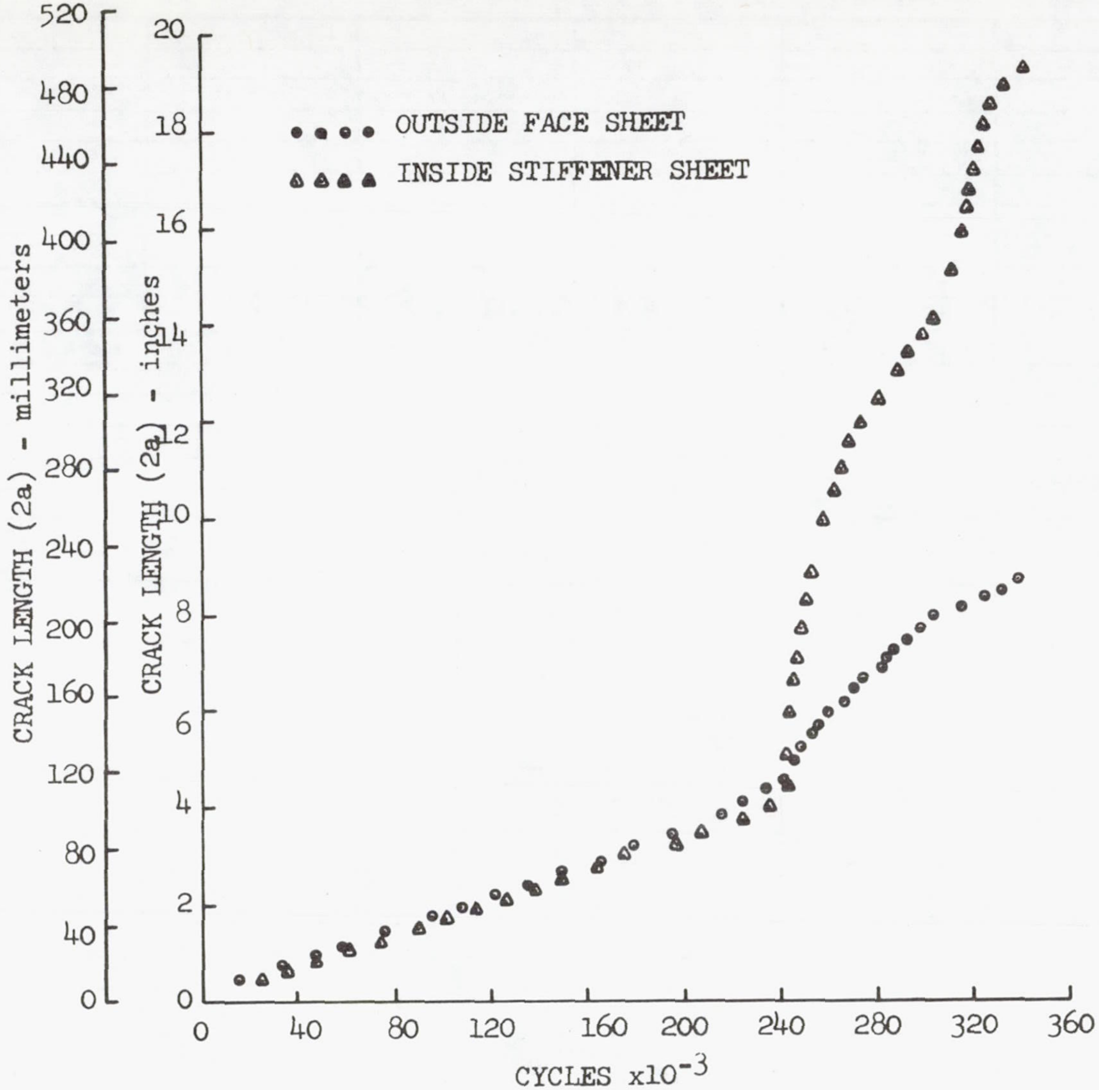

FIGURE F-38 CRACK GROWTH CURVE FOR ALUMINUM-GLASS PANEL #10C
(Crack Length Includes Secondary Cracks)

PANEL #11C

MATERIALS: ALUMINUM - GLASS

ADHESIVE: AF 126

ALUMINUM STRESS: 172 MN/m^2 (25 ksi)

MAXIMUM FATIGUE LOAD: 124,540N (28,000 lbf)

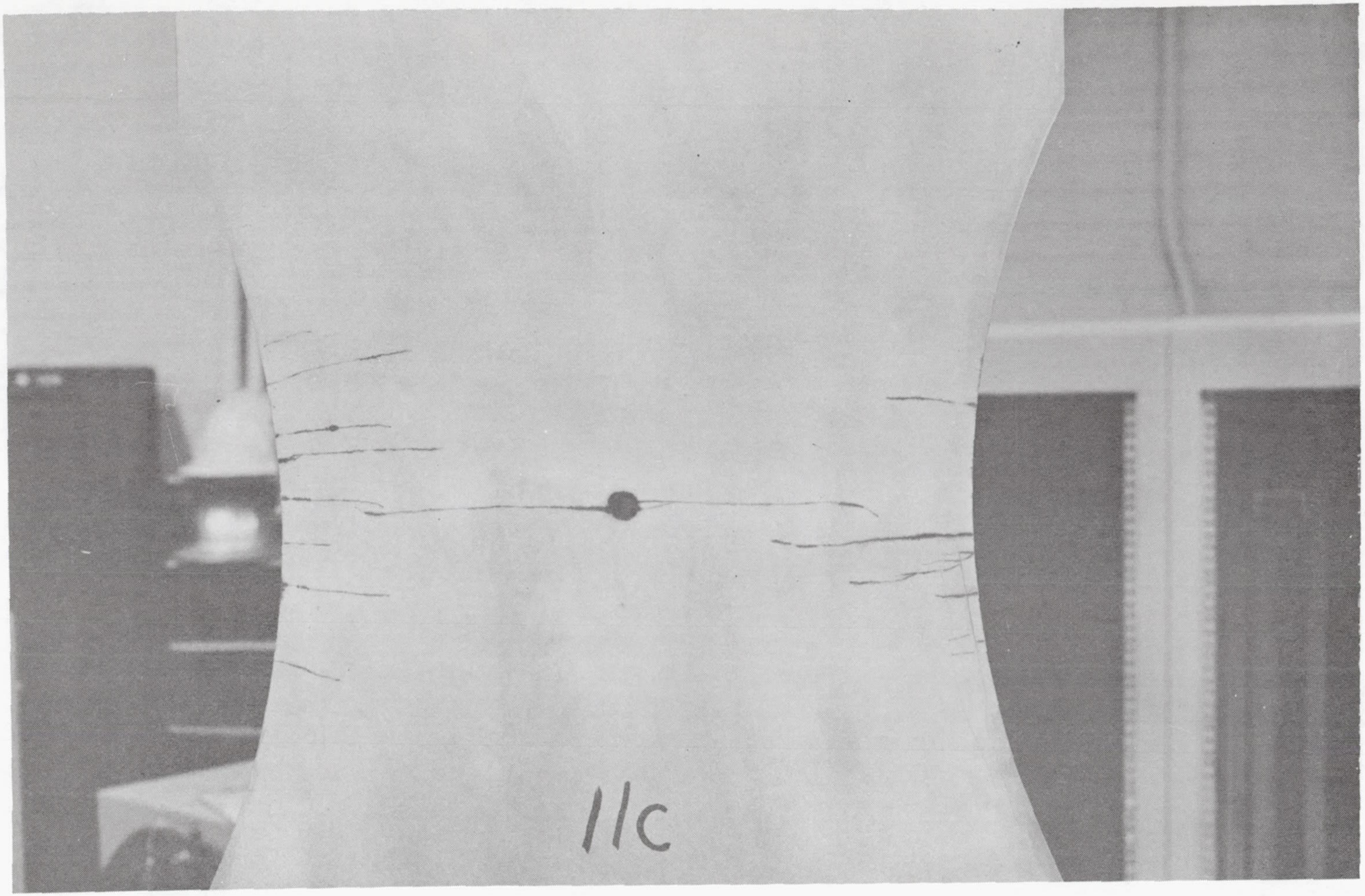

FIGURE F-39 OUTSIDE FACE SHEET AFTER CRACK GROWTH TEST - PANEL #11C

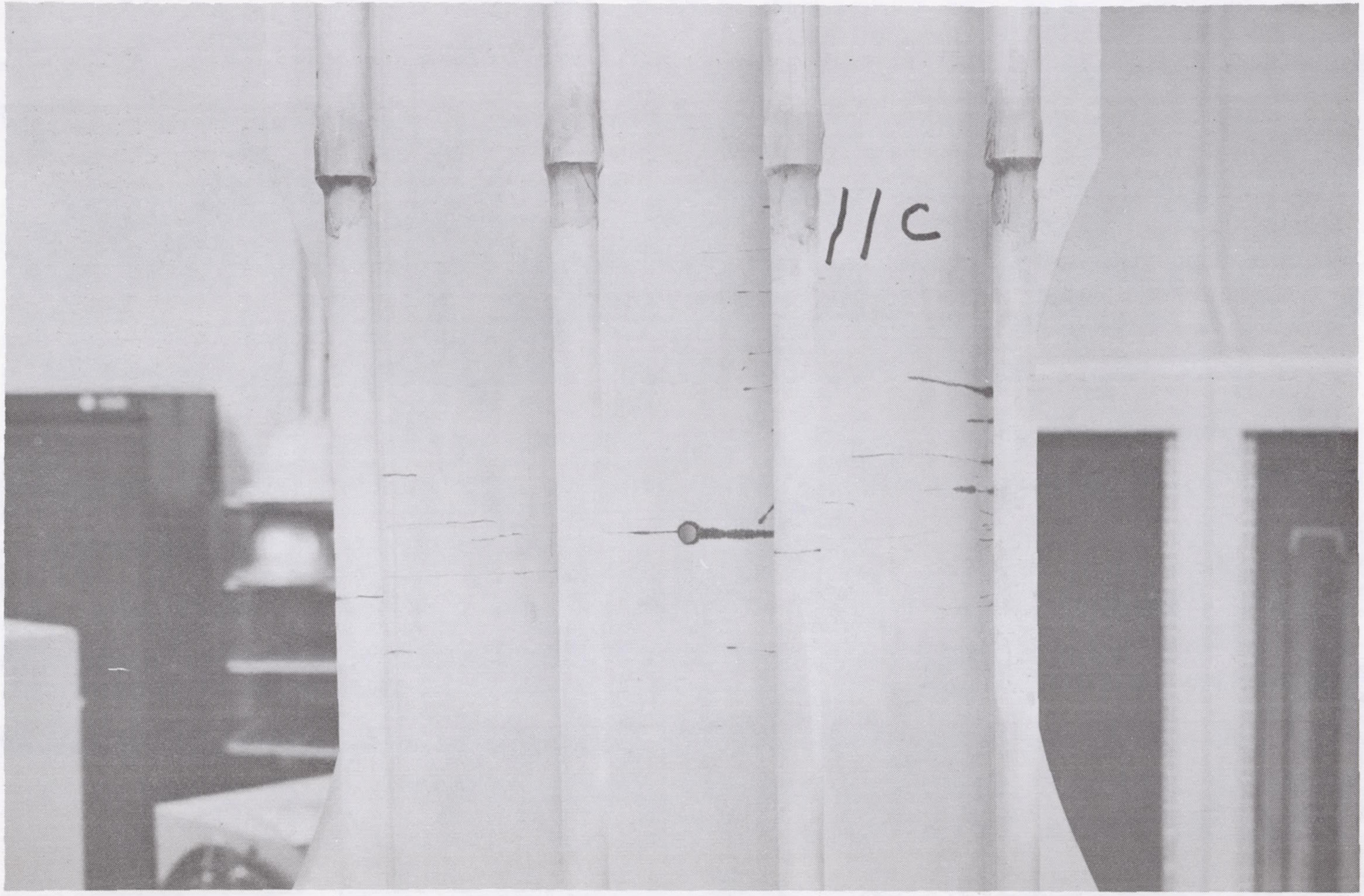

FIGURE F-40 INSIDE STIFFENER SHEET AFTER CRACK GROWTH TEST - PANEL #11C

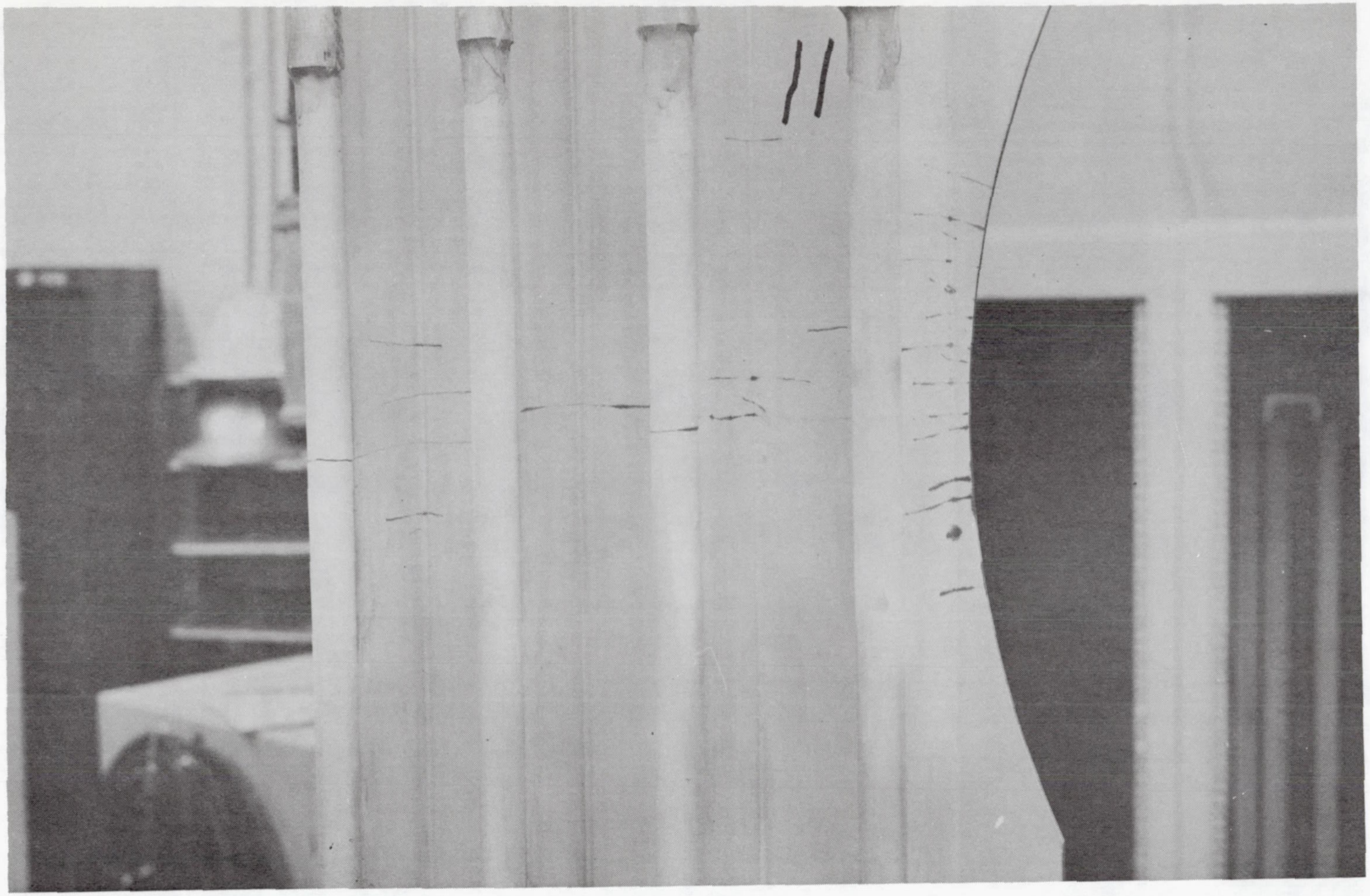

FIGURE F-41 INSIDE STIFFENER SHEET AFTER CRACK GROWTH TEST - PANEL #11C (RIGHT OF CENTERLINE)

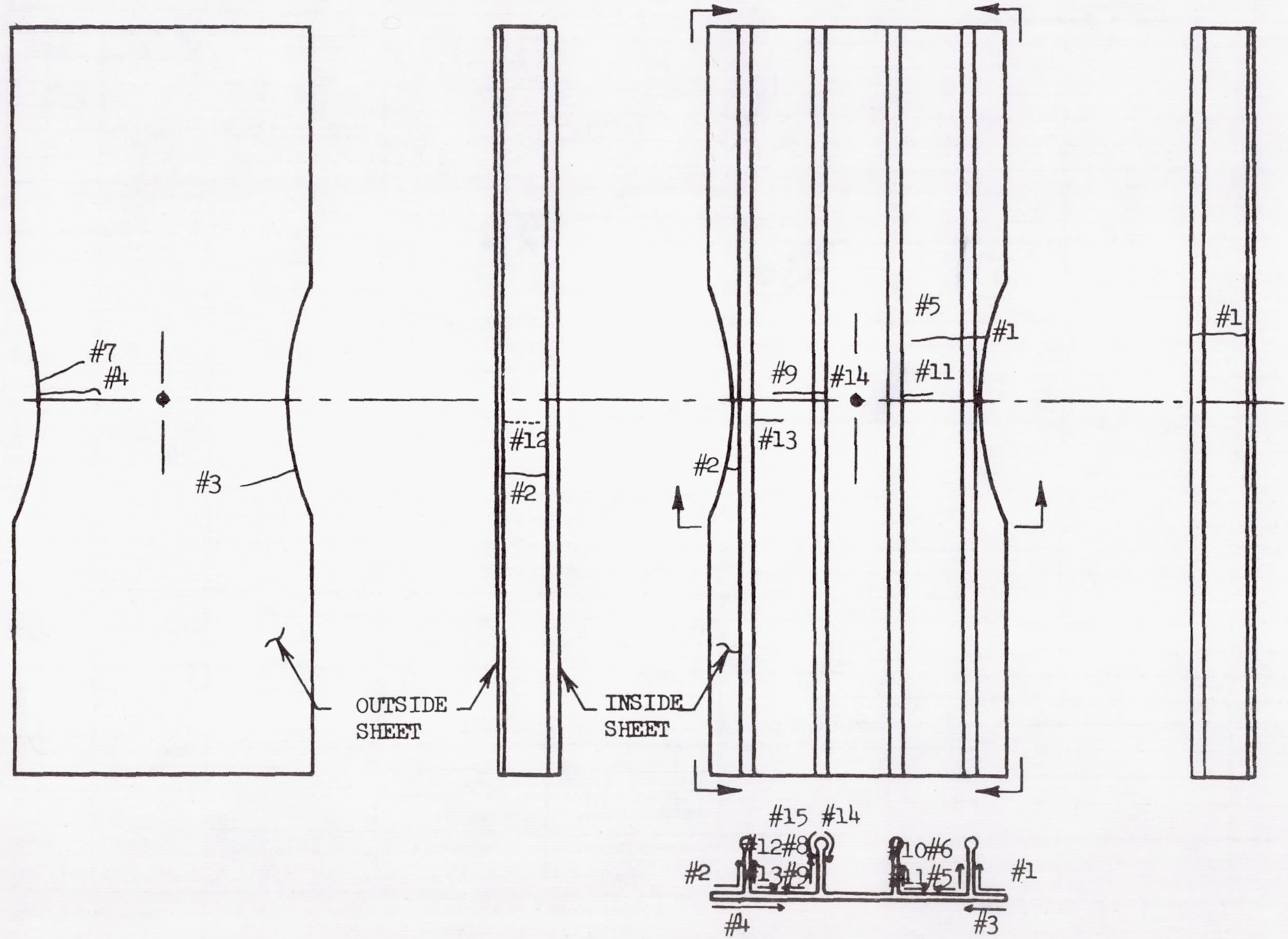

FIGURE F-42 SECONDARY CRACK LOCATIONS
ALUMINUM-GLASS PANEL #11C

Panel No. 11C		Primary Crack Lengths millimeters (inches)				Secondary Crack Lengths millimeters (inches)		
Cycle Rate	No. of Cycles	L/H Outside	R/H Outside	L/H Inside	R/H Inside			
9 Hz	13,200			3.2 (.125)				
	14,700			5.1 (.20)				
	15,500	6.4 (.25)						
	16,500		6.4 (.25)					
	17,000			6.4 (.25)				
	18,900	7.6 (.30)						
	19,500		7.6 (.30)					
	19,800			7.6 (.30)				
	20,100				5.1 (.20)			
	21,200				6.4 (.25)			
	21,400	8.9 (.35)						
	21,600		8.9 (.35)					
	22,000			8.9 (.35)				
	22,600	10.2 (.40)						
	22,800				7.6 (.30)			
	24,400		10.2 (.40)					
	24,900			10.2 (.40)				
	25,600				8.9 (.35)			
	26,300	11.4 (.45)						
	27,100			11.4 (.45)				
	27,900		11.4 (.45)					
	28,300	12.7 (.50)						
	28,400				10.2 (.40)			
	29,400		12.7 (.50)					
	30,200			12.7 (.50)				
	31,300	14.0 (.55)						
	32,300		14.0 (.55)		11.4 (.45)			
	33,400			14.0 (.55)				
	34,100				12.7 (.50)			
	34,600		15.2 (.60)					
	35,200	15.2 (.60)						
9 Hz	35,400			15.2 (.60)				

Panel No. 11C		Primary Crack Lengths millimeters (inches)				Secondary Crack Lengths millimeters (inches)		
Cycle Rate	No. of Cycles	L/H Outside	R/H Outside	L/H Inside	R/H Inside			
9 Hz	36,800	16.5 (.65)						
	37,600				14.0 (.55)			
	38,100			16.5 (.65)				
	38,400		16.5 (.65)					
	39,400	17.8 (.70)						
	40,000			17.8 (.70)	15.2 (.60)			
	41,400		17.8 (.70)					
	42,500	19.0 (.75)						
	42,700				16.5 (.65)			
	43,000			19.0 (.75)				
	45,300			20.3 (.80)				
	45,800				17.8 (.70)			
	46,000	20.3 (.80)	19.0 (.75)					
	47,000				19.0 (.75)			
	47,200			21.6 (.85)				
	48,400	21.6 (.85)						
	48,800		20.3 (.80)					
	49,500			22.9 (.90)				
	50,000		21.6 (.85)					
	50,300				20.3 (.80)			
	50,800	22.9 (.90)						
	51,100		22.9 (.90)					
	52,900				21.6 (.85)			
	53,200	24.1 (.95)						
	54,200		24.1 (.95)					
	55,400			25.4 (1.00)				
	56,100				22.9 (.90)			
	57,100		25.4 (1.00)					
	57,500	25.4 (1.00)						
	58,600			26.7 (1.05)				
	59,000		26.7 (1.05)					
9 Hz	59,400				24.1 (.95)			

Panel No. 11C		Primary Crack Lengths millimeters (inches)				Secondary Crack Lengths millimeters (inches)		
Cycle Rate	No. of Cycles	L/H Outside	R/H Outside	L/H Inside	R/H Inside			
9 Hz	59,900	26.7 (1.05)						
	60,600		27.9 (1.10)					
	60,700			27.9 (1.10)				
	61,200				25.4 (1.00)			
	61,500	27.9 (1.10)						
	63,200		29.2 (1.15)					
	63,600				26.7 (1.05)			
	64,000			29.2 (1.15)				
	65,600		30.5 (1.20)					
	66,000	29.2 (1.15)						
	66,100			30.5 (1.20)				
	66,900				27.9 (1.10)			
	68,300	30.5 (1.20)	31.8 (1.25)					
	68,500			31.8 (1.25)				
	69,800				29.2 (1.15)			
	71,300		33.0 (1.30)					
9 Hz	72,091			33.0 (1.30)	30.5 (1.20)			
5 Hz	74,591	31.8 (1.25)						
	74,991		34.3 (1.35)					
	75,491			34.3 (1.35)	31.8 (1.25)			
	77,091		35.6 (1.40)					
	77,291	33.0 (1.30)						
	80,591	34.3 (1.35)						
	81,091			35.6 (1.40)	33.0 (1.30)			
	81,991	35.6 (1.40)						
	82,091		36.8 (1.45)					
	82,391				34.3 (1.35)			
	83,391			36.8 (1.45)				
5 Hz	83,991		38.1 (1.50)					
6 Hz	85,491	36.8 (1.45)						
	85,691				35.6 (1.40)			
6 Hz	87,791			38.1 (1.50)				

Panel No. 11C		Primary Crack Lengths millimeters (inches)				Secondary Crack Lengths millimeters (inches)		
Cycle Rate	No. of Cycles	L/H Outside	R/H Outside	L/H Inside	R/H Inside	#1		
6 Hz	87,891		39.4 (1.55)					
	89,991				36.8 (1.45)			
	90,291	38.1 (1.50)						
	90,991		40.6 (1.60)					
	92,491	39.4 (1.55)						
	93,691			39.4 (1.55)				
	93,791				38.1 (1.50)			
	94,691		41.9 (1.65)					
	95,291	40.6 (1.60)						
	97,091			40.6 (1.60)				
	97,391		43.2 (1.70)					
	98,691				39.4 (1.55)			
	98,891	41.9 (1.65)						
	100,991		44.4 (1.75)					
	101,891	43.2 (1.70)						
	102,391				40.6 (1.60)			
	102,991			41.9 (1.65)				
	104,991		45.7 (1.80)					
	105,691			43.2 (1.70)				
	106,291	44.4 (1.75)						
	107,491				41.9 (1.65)			
	108,691		47.0 (1.85)	44.4 (1.75)				
	111,091				43.2 (1.70)			
	111,191			45.7 (1.80)				
6 Hz	111,226	45.7 (1.80)						
5 Hz	112,626		48.3 (1.90)					
	115,626	47.0 (1.85)			44.4 (1.75)			
	116,626			47.0 (1.85)				
	117,226		49.5 (1.95)					
	119,226					1.3 (.05)		
	119,626		50.8 (2.00)					
5 Hz	120,126				45.7 (1.80)			

Panel No. 11C		Primary Crack Lengths millimeters (inches)				Secondary Crack Lengths millimeters (inches)		
Cycle Rate	No. of Cycles	L/H Outside	R/H Outside	L/H Inside	R/H Inside	#1	#2	#3
5 Hz	121,426							10.2 (.40)
	121,626						1.3 (.05)	
	122,526			48.3 (1.90)				
	122,726	49.5 (1.95)						
	123,326		52.1 (2.05)					
	123,726				47.0 (1.85)			
	126,226	50.8 (2.00)						12.7 (.50)
	126,326			49.5 (1.95)				
	126,626		53.3 (2.10)					
	127,126						2.5 (.10)	
	128,226							
	129,226				48.3 (1.90)			
	129,926	52.1 (2.05)	54.6 (2.15)					
	131,526			50.8 (2.00)	49.5 (1.95)			
	134,226	53.3 (2.10)						
	135,026		55.9 (2.20)					
	135,826			52.1 (2.05)				
	136,226					35.6 (1.40)		
	136,326		57.2 (2.25)					
	136,426	54.6 (2.15)						
	136,826				50.8 (2.00)		5.1 (.20)	
	138,526							17.8 (.70)
	139,926	55.9 (2.20)	58.4 (2.30)					
	140,226				52.1 (2.05)			
	140,626			53.3 (2.10)				
	140,726					38.1 (1.50)		
	142,226							
	143,026	57.2 (2.25)	59.7 (2.35)					
	143,526							
	143,726							20.3 (.80)
	143,826							
.5 Hz	144,026				53.3 (2.10)			

Panel No. 11C		Secondary Crack Lengths millimeters (inches)						
Cycle Rate	No. of Cycles	#4						
5 Hz	121,426							
	121,626							
	122,526							
	122,726							
	123,326							
	123,726							
	126,226							
	126,326							
	126,626							
	127,126							
	128,226	10.2 (.40)						
	129,226							
	129,926							
	131,526							
	134,226							
	135,026							
	135,826							
	136,226							
	136,326							
	136,426							
	136,826	20.3 (.80)						
	138,526							
	139,926							
	140,226							
	140,626							
	140,726	22.9 (.90)						
	142,226							
	143,026							
	143,526	25.4 (1.00)						
	143,726							
	143,826							
5 Hz	144,026							

Panel No. 11C		Primary Crack Lengths millimeters (inches)				Secondary Crack Lengths millimeters (inches)		
Cycle Rate	No. of Cycles	L/H Outside	R/H Outside	L/H Inside	R/H Inside	#1	#2	#3
5 Hz	144,926							
	145,126	58.4 (2.30)	61.0 (2.40)					
	146,426						7.6 (.30)	
	146,826							
	147,326	59.7 (2.35)	62.2 (2.45)					
	148,426							
	149,026				54.6 (2.15)			
	150,626	61.0 (2.40)	63.5 (2.50)					
	151,026							22.9 (.90)
	151,126							
	151,726					40.6 (1.60)		
	152,426						10.2 (.40)	
	152,526		64.8 (2.55)					
	153,826	62.2 (2.45)						
	154,826		66.0 (2.60)					
	155,126							
	155,226							
	155,426			55.9 (2.20)				
	155,826							
	156,926	63.5 (2.50)			55.9 (2.20)			
	157,626		67.3 (2.65)					
	157,926							
	158,326	64.8 (2.55)						
	158,526							25.4 (1.00)
	158,626				57.2 (2.25)			
	159,126			57.2 (2.25)				
	159,326							
	160,326							
	160,626							
	161,026		68.9 (2.70)					
	161,226							
5 Hz	162,826	66.0 (2.60)	69.8 (2.75)					

Panel No. 11C		Secondary Crack Lengths millimeters (inches)						
Cycle Rate	No. of Cycles	#4	#5	#6	#8	#9		
5 Hz	144,926		7.6 (.30)					
	145,126							
	146,426							
	146,826	27.9 (1.10)						
	147,326							
	148,426		10.2 (.40)					
	149,026							
	150,626							
	151,026							
	151,126	33.0 (1.30)						
	151,726		12.7 (.50)					
	152,426							
	152,526							
	153,826							
	154,826							
	155,126	35.6 (1.40)						
	155,226			7.6 (.30)				
	155,426							
	155,826		17.8 (.70)					
	156,926							
	157,626							
	157,926				10.2 (.40)			
	158,326							
	158,526							
	158,626							
	159,126							
	159,326				11.4 (.45)			
	160,326					16.5 (.65)		
	160,626	38.1 (1.50)						
	161,026							
	161,226	40.6 (1.60)	20.3 (..80)	10.2 (.40)				
5 Hz	162,826							

Panel No. 11C		Primary Crack Lengths millimeters (inches)				Secondary Crack Lengths millimeters (inches)		
Cycle Rate	No. of Cycles	L/H Outside	R/H Outside	L/H Inside	R/H Inside	#1	#2	#3
5 Hz	163,426	67.3 (2.65)						
	163,626							
	163,826							27.9 (1.10)
	163,926				58.4 (2.30)			
	164,026							
	164,226							
	164,726			58.4 (2.30)				
	164,826					45.7 (1.80)		
	165,226						12.7 (.50)	
	165,326							
	165,426	68.6 (2.70)	71.1 (2.80)					
	165,726							
	166,126							
	167,926	69.8 (2.75)	72.4 (2.85)					
	168,226							
	168,426				59.7 (2.35)			
	168,726					48.3 (1.90)		
	169,026		73.7 (2.90)			Crack		
	169,326			59.7 (2.35)		Stopped		
	169,426					in Bulb		
	169,726					Radius		
	170,226		74.9 (2.95)					
	170,526	71.1 (2.80)						
	170,826							30.5 (1.20)
	171,326				61.0 (2.40)			
	172,726							
	172,826							
	173,026	72.4 (2.85)	76.2 (3.00)					
	173,526	Overlap #4						33.0 (1.30)
	173,726	Secondary	77.5 (3.05)					
	174,026	Crack						
5 Hz	174,126			61.0 (2.40)		48.3 (1.90)		

Panel No. 11C		Secondary Crack Lengths millimeters (inches)						
Cycle Rate	**No. of Cycles**	#4	#5	#6	#8	#9	#10	#11
5 Hz	163,426							
	163,626					19.0 (.75)		
	163,826	43.2 (1.70)						
	163,926							
	164,026				12.7 (.50)			
	164,226		22.9 (.90)					
	164,726							
	164,826							
	165,226							
	165,326					21.6 (.85)		
	165,426							
	165,726				14.0 (.55)			
	166,126	45.7 (1.80)						
	167,926							
	168,226		25.4 (1.00)	12.7 (.50)				
	168,426							
	168,726							
	169,026							
	169,326							
	169,426					26.7 (1.05)		
	169,726				15.2 (.60)			
	170,226							
	170,526							
	170,826	48.3 (1.90)	27.9 (1.10)					
	171,326							
	172,726							6.4 (.25)
	172,826						6.4 (.25)	
	173,026	←Overlaps						
	173,526	L/H Primary	30.5 (1.20)					
	173,726	Crack						
	174,026					31.8 (1. 25)		
5 Hz	174,126							

Panel No. 11C		Secondary Crack Lengths millimeters (inches)						
Cycle Rate	No. of Cycles	#12	#13					
5 Hz	163,426							
	163,626							
	163,826							
	163,926							
	164,026							
	164,226							
	164,726							
	164,826							
	165,226							
	165,326							
	165,426							
	165,726							
	166,126							
	167,926							
	168,226							
	168,426							
	168,726							
	169,026							
	169,326							
	169,426							
	169,726							
	170,226							
	170,526							
	170,826							
	171,326							
	172,726		6.4 (.25)					
	172,826	6.4 (.25)						
	173,026							
	173,526							
	173,726							
	174,026							
5 Hz	174,126							

Panel No. 11C		Primary Crack Lengths millimeters (inches)				Secondary Crack Lengths millimeters (inches)		
Cycle Rate	No. of Cycles	L/H Outside	R/H Outside	L/H Inside	R/H Inside	#1	#2	#3
5 Hz	175,626		78.7 (3.10)			48.3 (1.90)		
	176,126	74.9 (2.95)						
	176,426							35.6 (1.40)
	176,626							
	176,726							
	176,826							
	177,526							
	177,626				62.2 (2.45)			
	177,726		80.0 (3.15)					
	178,326							
	178,526	76.2 (3.00						
	178,626			62.2 (2.45)				
	178,726		81.3 (3.20)					
	178,826							
	178,926							
	179,526							
	179,626							
	180,326							
	180,426				63.5 (2.50)			
	181,026	77.5 (3.05)	82.6 (3.25)	63.5 (2.50)				
	181,326							
	181,426							
	181,526		Overlaps #3					38.1 (1.50)
	181,726		Secondary	64.8 (2.55)				Overlaps
	181,826		Crack 83.8 (3.30)					R/H Primary
	182,026							Crack
	182,226	78.7 (3.10)						
	182,426							
	183,026							
	183,126			66.0 (2.60)				
	183,526							
5 Hz	184,026					48.3 (1.90)		

Panel No. 11C		Secondary Crack Lengths millimeters (inches)						
Cycle Rate	No. of Cycles	#4	#5	#6	#8	#9	#10	#11
5 Hz	175,626							
	176,126							
	176,426		33.0 (1.30)					
	176,626						8.9 (.35)	
	176,726							11.4 (.45)
	176,826	53.3 (2.10)						
	177,526				17.8 (.70)	34.3 (1.35)		
	177,626							
	177,726							
	178,326							16.5 (.65)
	178,526							
	178,626							
	178,726							
	178,826							
	178,926	55.9 (2.20)					10.2 (.40)	10.2 (.40)
	179,526							
	179,626		35.6 (1.40)		20.3 (.80)			
	180,326							
	180,426							
	181,026							
	181,326	58.4 (2.30)					12.7 (.50)	
	181,426							21.6 (.85)
	181,526							
	181,726							
	181,826							
	182,026							
	182,226					39.4 (1.55)		
	182,426				21.6 (.85)			
	183,026							24.11 (.95)
	183,126							
	183,526						15.2 (.60)	
5 Hz	184,026					41.9 (1.65)		

Panel No. 11C		Secondary Crack Lengths millimeters (inches)						
Cycle Rate	No. of Cycles		#12 Secondary	#13 Secondary	#14 Secondary	#15 Secondary		
5 Hz	175,626				1.3 (.05)			
	176,126							
	176,426							
	176,626		8.9 (.35)					
	176,726			11.4 (.45)				
	176,826							
	177,526							
	177,626							
	177,726							
	178,326			16.5 (.65)				
	178,526							
	178,626							
	178,726							
	178,826				3.8 (.15)			
	178,926		10.2 (.40)					
	179,526					5.1 (.20)		
	179,626							
	180,326					6.4 (.25)		
	180,426				6.4 (.25)			
	181,026							
	181,326		12.7 (.50)					
	181,426			21.6 (.85)				
	181,526							
	181,726							
	181,826							
	182,026				7.6 (.30)			
	182,226					7.6 (.30)		
	182,426							
	183,026				8.9 (.35)			
	183,126							
	183,526		15.2 (.60)					
5 Hz	184,026							

Panel No. 11C		Primary Crack Lengths millimeters (inches)				Secondary Crack Lengths millimeters (inches)		
Cycle Rate	No. of Cycles	L/H Outside	R/H Outside	L/H Inside	R/H Inside	#1 Secondary	#2 Secondary	#3 Secondary
5 Hz	184,326				64.8 (2.55)	48.3 (1.90)		
	184,726							
	185,026		86.4 (3.40)					
	185,226	80.0 (3.15)		67.3 (2.65)				
	185,426		87.6 (3.45)	Overlaps				
	185,626			#14				
	185,726			Secondary				
	185,926			Crack				
	186,026							40.6 (1.60)
	186,126		88.9 (3.50)					
	186,226							
	186,326	81.3 (3.20)						
	186,426							
	187,026							
	187,326							
	187,426							
	187,626							
	188,126				66.0 (2.60)			
	188,726							
	189,226							
	189,726							
	189,926							
	191,026							
	191,826				67.3 (2.65)			
	192,126							
	192,826							
	193,226	83.8 (3.30)	91.4(3.60)					
	193,726							
	193,826							43.2 (1.70)
	194,126							
	194,426							
5 Hz	194,526	85.1 (3.35)				48.3 (1.90)		

Panel No. 11C		Secondary Crack Lengths millimeters (inches)						
Cycle Rate	No. of Cycles	#4	#5	#6	#8	#9	#10	#11
5 Hz	184,326							
	184,726		40.6 (1.60)		24.1 (.95)			
	185,026							
	185,226							
	185,426							
	185,626						16.5 (.65)	29.2 (1.15)
	185,726	63.5 (2.50)						
	185,926				25.4 (1.00)			
	186,026							
	186,126							
	186,226				26.7 (1.05)			
	186,326							
	186,426				← Overlaps #15			
	187,026		43.2 (1.70)		Secondary	47.0 (1.85)		
	187,326				Crack	Overlaps	17.8 (.70)	
	187,426		← Overlaps			#13		31.8 (1.25)
	187,626		#11			Secondary		Overlap #5
	188,126		Secondary			Crack		Secondary
	188,726		Crack					Crack
	189,226						20.3 (.80)	
	189,726							34.3 (1.35)
	189,926						21.6 (.85)	
	191,026						22.9 (.90)	
	191,826							
	192,126					54.6 (2.15)		36.8 (1.45)
	192,826						24.1 (.95)	
	193,226							
	193,726					57.2 (2.25)		
	193,826							
	194,126	68.6 (2.70)						
	194,426						25.4 (1.00)	
5 Hz	194,526							

Panel No. 11C		Secondary Crack Lengths millimeters (inches)						
Cycle Rate	No. of Cycles	#12	#13	#14	#15			
5 Hz	184,326							
↑	184,726				11.4 (.45)			
	185,026							
	185,226			10.2 (.40)				
	185,426			Overlaps				
	185,626	16.5 (.65)	29.2 (1.15)	L/H Primary				
	185,726			Crack				
	185,926							
	186,026							
	186,126							
	186,226				14.0 (.55)			
	186,326							
	186,426				15.2 (.60)			
	187,026		← Overlaps #9		Overlaps			
	187,326	17.8 (.70)	Secondary		#8			
	187,426		Crack		Secondary			
	187,626			11.4 (.45)	Crack			
	188,126							
	188,726			12.7 (.50)				
	189,226	20.3 (.80)						
	189,726		34.3 (1.35)					
	189,926	21.6 (.85)						
	191,026	22.9 (.90)						
	191,826							
	192,126		36.8 (1.45)					
	192,826	24.1 (.95)						
	193,226							
	193,726							
	193,826							
	194,126							
↓	194,426	25.4 (1.00)						
5 Hz	194,526							

Panel No. 11C		Primary Crack Lengths millimeters (inches)				Secondary Crack Lengths millimeters (inches)		
Cycle Rate	No. of Cycles	L/H Outside	R/H Outside	L/H Inside	R/H Inside	#1	#2	#3
5 Hz	194,826		92.7 (3.65)			48.3 (1.90)		
	196,026				68.6 (2.70)			
	197,026							
	197,226							
	197,426							
	199,326				69.8 (2.75)			
	199,526							
	199,826							
	201,226		94.0 (3.70)					
	201,326	86.4 (3.40)						
	201,626							
	203,426							
	203,526				71.1 (2.80)			
	205,526							
5 Hz	206,476	87.6 (3.45)	95.2 (3.75)			48.3 (1.90)	48.3 (1.90)	
Final Crack Lengths		87.6 (3.45)	95.2 (3.75)	67.3 (2.65)	71.1 (2.80)	48.3 (1.90)	48.3 (1.90)	43.2 (1.70)
	Residual strength =		257,500N	(57,900 lbs)				

Panel No. 11C		Secondary Crack Lengths millimeters (inches)						
Cycle Rate	No. of Cycles	#4	#5	#6	#8	#9	#10	#11
5 Hz	194,826							
	196,026							
	197,026						26.7 (1.05)	
	197,226					59.7 (2.35)		
	197,426							39.4 (1.55)
	199,326							
	199,526						27.9 (1.10)	
	199,826					64.8 (2.55)		
	201,226							
	201,326							
	201,626						29.2 (1.15)	
	203,426						30.5 (1.20)	
	203,526							
	205,526						31.8 (1.25)	
5 Hz	206,476			41.9 (1.65)				
Final crack Lengths		68.6 (2.70)	43.2 (1.70)	41.9 (1.65)	26.7 (1.05)	64.8 (2.55)	31.8 (1.25)	39.4 (1.55)

Panel No. 11C		Secondary Crack Lengths millimeters (inches)						
Cycle Rate	No. of Cycles	#12	#13	#14	#15			
5 Hz	194,826							
↑	196,026							
	197,026	26.7 (1.05)						
	197,226							
	197,426		39.4 (1.55)					
	199,326							
	199,526	27.9 (1.10)						
	199,826							
	201,226							
	201,326							
	201,626	29.2 (1.15)						
	203,426	30.5 (1.20)						
	203,526							
↓	205,526	31.8 (1.25)						
5 Hz	206,476							
Final Crack Lengths		31.8 (1.25)	39.4 (1.55)	12.7 (.50)	15.2 (.60)			

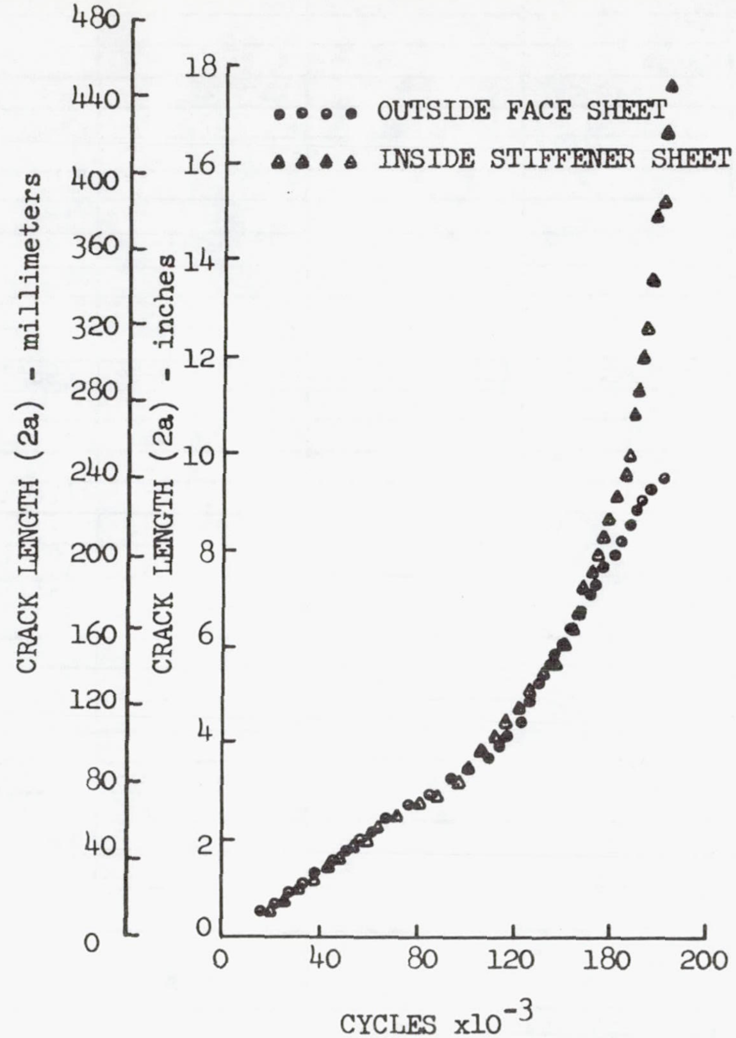

FIGURE F-43 CRACK GROWTH CURVE FOR ALUMINUM-GLASS PANEL #11C
(Crack Length Includes Secondary Cracks)

PANEL #12C

MATERIALS: ALUMINUM - GRAPHITE

ADHESIVE: EA-927R

ALUMINUM STRESS: 172 MN/m^2 (25 ksi)

MAXIMUM FATIGUE LOAD: 200,160N (45,000 lbf)

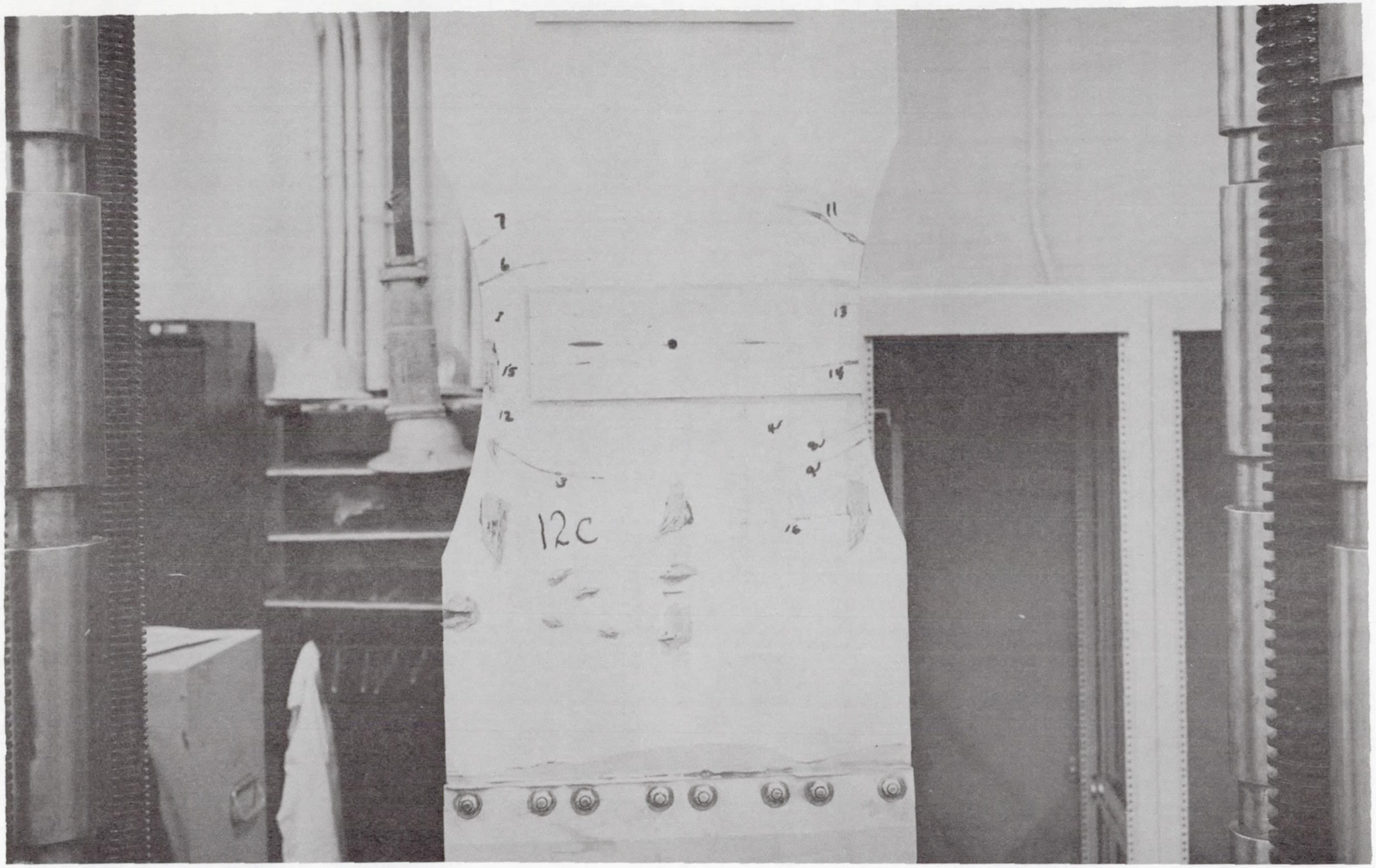

FIGURE F-44 OUTSIDE FACE SHEET AFTER CRACK GROWTH TEST - PANEL #12C

FIGURE F-45 INSIDE STIFFENER SHEET AFTER CRACK GROWTH TEST - PANEL #12C

FIGURE F-46 INSIDE STIFFENER SHEET AFTER CRACK GROWTH TEST - PANEL #12C (RIGHT OF CENTERLINE)

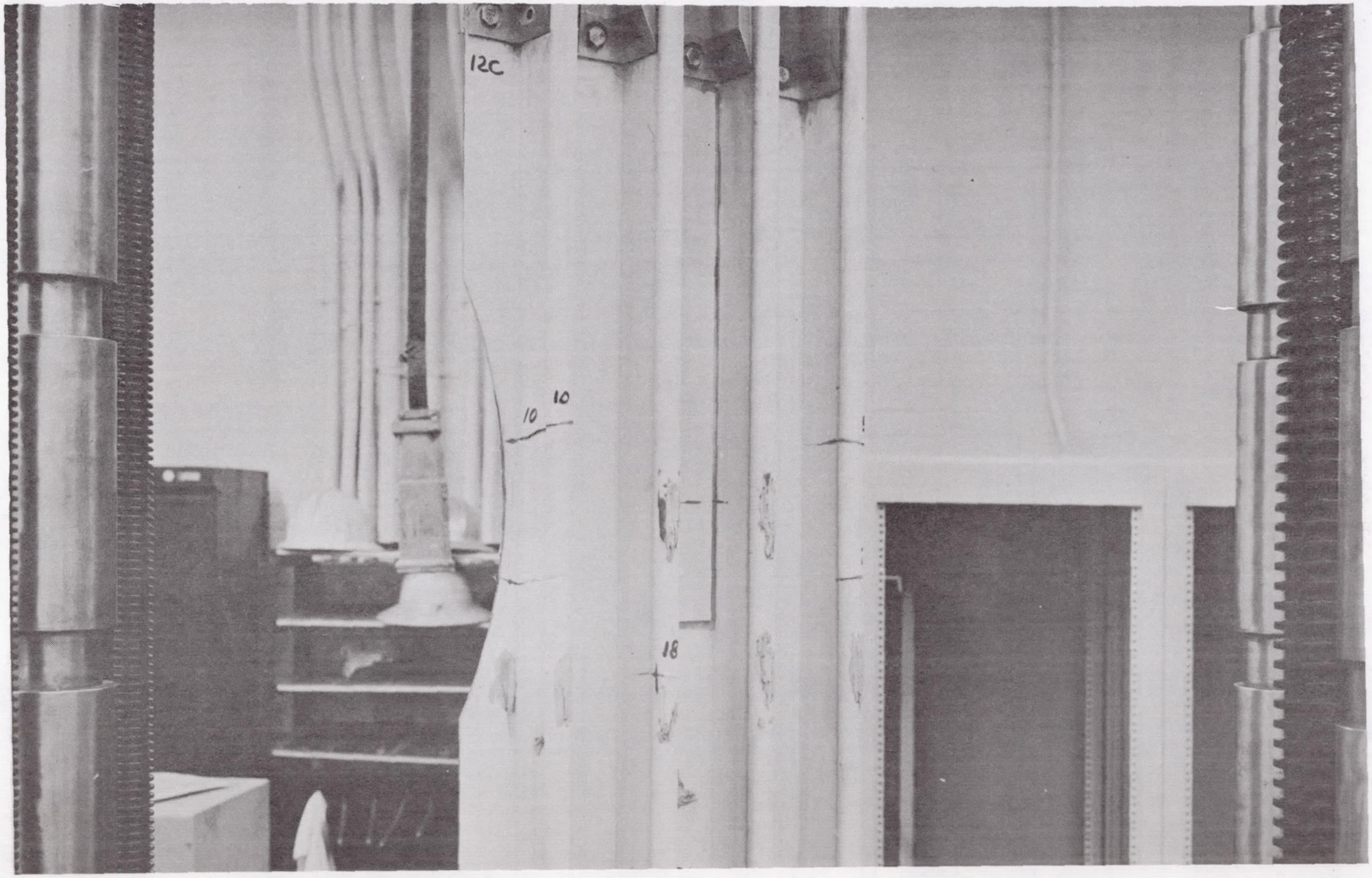

FIGURE F-47 INSIDE STIFFENER SHEET AFTER CRACK GROWTH TEST - PANEL #12C (LEFT OF CENTERLINE)

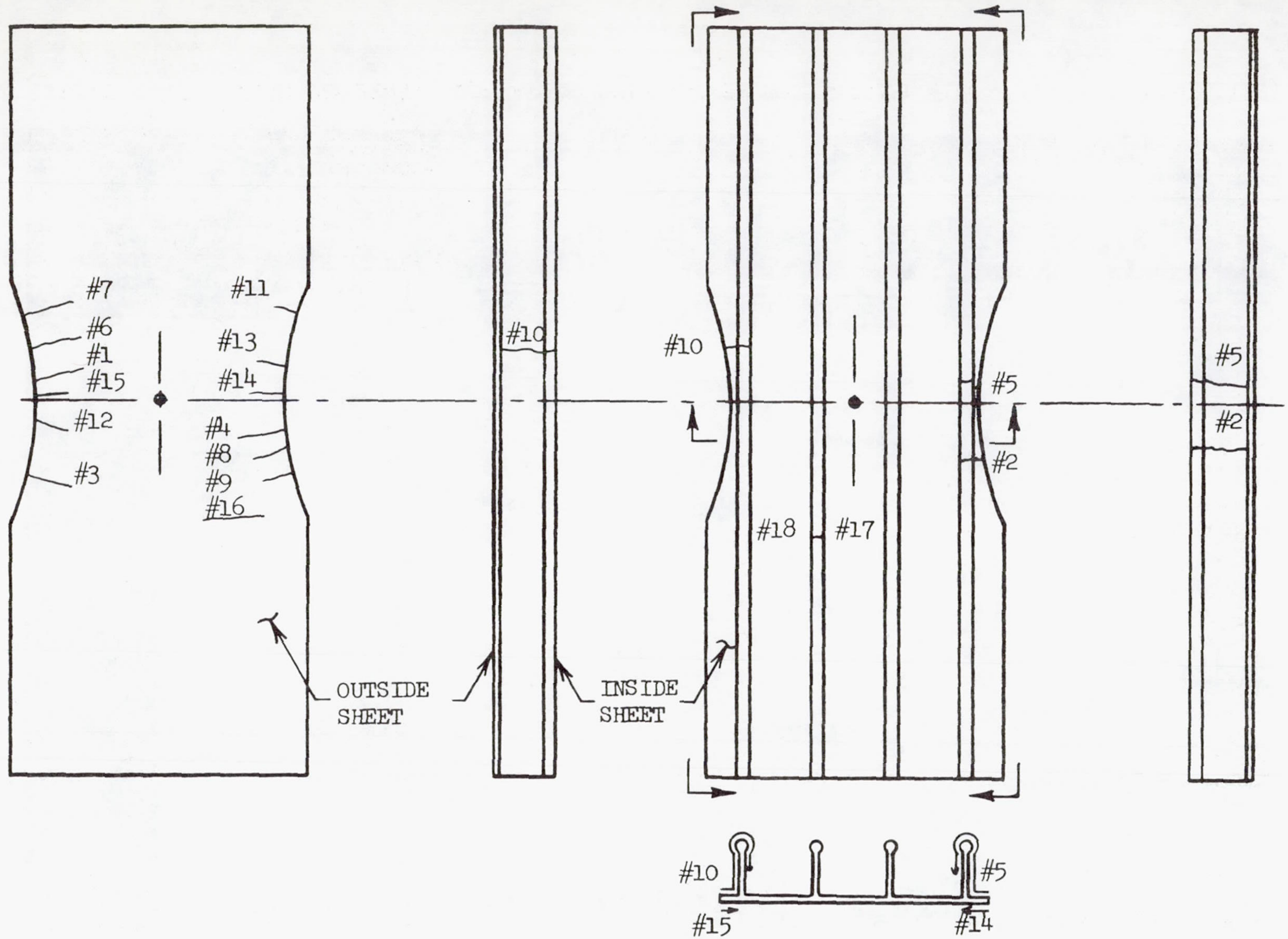

FIGURE F-48 SECONDARY CRACK LOCATIONS
ALUMINUM-GRAPHITE PANEL #12C

Panel No. 12C		Primary Crack Lengths millimeters (inches)				Secondary Crack Lengths millimeters (inches)		
Cycle Rate	No. of Cycles	L/H Outside	R/H Outside	L/H Inside	R/H Inside	L/H Edge Outside	R/H Edge Inside	
4 Hz	6,500	5.1 (.20)	6.4 (.25)					
	8,200	6.4 (.25)	7.6 (.30)					
	10,600	7.6 (.30)	8.9 (.35)	3.8 (.15)				
	13,100	8.9 (.35)						
	13,300		10.2 (.40)					
	13,700			5.1 (.20)	5.1 (.20)			
	15,000	10.2 (.40)			6.4 (.25)			
	15,400			6.4 (.25)				
	18,200	11.4 (.45)	11.4 (.45)					
	18,400				7.6 (.30)			
	21,000			7.6 (.30)				
	21,500	12.7 (.50)						
	21,700		12.7 (.50)		8.9 (.35)			
	24,700	14.0 (.55)						
	24,900			8.9 (.35)				
	28,000	15.2 (.60)	14.0 (.55)					
	31,400		15.2 (.60)					
	32,000			10.2 (.40)	10.2 (.40)			
	37,000	16.5 (.65)	16.5 (.65)					
	37,300			11.4 (.45)				
	37,500				11.4 (.45)			
	42,000	17.8 (.70)		12.7 (.50)				
	44,000		17.8 (.70)		12.7 (.50)			
	45,200	19.0 (.75)						
	45,600			14.0 (.55)				
	47,100		19.0 (.75)					
	49,800				14.0 (.55)			
	50,300	20.3 (.80)						
4 Hz	50,450		20.3 (.80)					
3 Hz	52,210			15.2 (.60)		10.2 (.60)	12.7 (.50)	
	55,000	21.6 (.85)					15.2 (.60)	
3 Hz	55,100			16.5 (.65)				

Panel No. 12C		Primary Crack Lengths millimeters (inches)				Secondary Crack Lengths millimeters (inches)		
Cycle Rate	No. of Cycles	L/H Outside	R/H Outside	L/H Inside	R/H Inside	L/H Edge Outside	R/H Edge Outside	L/H Edge Inside
3 Hz	55,400					11.4 (.45)		
	55,600		21.6 (.85)					
	57,200					12.7 (.50)		
	57,600	22.9 (.90)	22.9 (.90)					
	57,800				15.2 (.60)			
	59,200					14.0 (.55)		
	59,300							
	62,600			17.8 (.70)				
	62,800	24.1 (.95)				15.2 (.60)		
	63,000							
	63,600				16.5 (.65)			
	65,100		24.1 (.95)			16.5 (.65)		
	67,800							
	67,900			19.0 (.75)	17.8 (.70)			
	68,700					17.8 (.70)		
	69,000						2.5 (.10)	
	69,200	25.4 (1.00)	25.4 (1.00)					
	72,600	26.7 (1.05)						
	73,000			20.3 (.80)				
	73,500		26.7 (1.05)					
	73,700							
	73,800					19.0 (.75)		
	75,000						5.1 (.20)	
	75,200							3.8 (.15)
	75,400							
	76,400	27.9 (1.10)						
	76,700							5.1 (.20)
	79,800		27.9 (1.10)				7.6 (.30)	
	80,300					21.6 (.85)		
	80,500							
3 Hz	80,800				19.0 (.75)			
4 Hz	81,300					22.9 (.90)		

Panel No. 12C		Secondary Crack Lengths millimeters (inches)					
Cycle Rate	No. of Cycles	R/H Edge Inside					
3 Hz	55,400						
	55,600						
	57,200						
	57,600	17.8 (.70)					
	57,800						
	59,200						
	59,300	19.0 (.75)					
	62,600						
	62,800						
	63,000	20.3 (.80)					
	63,600						
	65,100						
	67,800	21.6 (.85)					
	67,900						
	68,700						
	69,000						
	69,200						
	72,600	22.9 (.90)					
	73,000						
	73,500						
	73,700	24.1 (.95)					
	73,800						
	75,000						
	75,200						
	75,400	25.4 (1.00)					
	76,400						
	76,700						
	79,800						
	80,300						
	80,500	26.7 (1.05)					
3 Hz	80,800						
4 Hz	81,300						

Panel No. 12C		Primary Crack Lengths millimeters (inches)				Secondary Crack Lengths millimeters (inches)		
Cycle Rate	No. of Cycles	L/H Outside	R/H Outside	L/H Inside	R/H Inside	L/H Edge Outside	R/H Edge Outside	L/H Edge Inside
4 Hz	82,500							6.4 (.25)
	82,600			21.6 (.85)				
	83,500	29.2 (1.15)						
	83,800						10.2 (.40)	
	83,850							7.6 (.30)
	85,500							8.9 (.35)
	87,100						12.7 (.50)	
	87,800							10.2 (.40)
	90,300	30.5 (1.20)	29.2 (1.15)					
	91,800							
	92,700							
	92,750			22.9 (.90)				
	92,900							15.2 (.60)
	93,500				20.3 (.80)			
	94,800						15.2 (.60)	
	95,000		30.5 (1.20)					
	95,200					25.4 (1.00)		
	95,400	21.8 (1.25)						
	97,900							
	103,000			24.1 (.95)				
	103,400							19.0 (.75)
	103,700							
	104,749	33.0 (1.30)	31.8 (1.25)			27.9 (1.10)	17.8 (.70)	
	106,649				21.6 (.85)			
	109,329			25.4 (1.00)				20.3 (.80)
	109,337	34.3 (1.35)	33.0 (1.30)				20.3 (.80)	
	111,749	35.6 (1.40)	34.3 (1.35)					
	111,849				22.9 (.90)			
	112,249							
	115,749			26.7 (1.05)				
	116,249							
4 Hz	117,249							22.9 (.90)

Panel No. 12C		Secondary Crack Lengths millimeters (inches)						
Cycle Rate	No. of Cycles	R/H Edge Inside						
4 Hz	82,500	27.9 (1.10)						
	82,600							
	83,500							
	83,800							
	83,850							
	85,500							
	87,100							
	87,800							
	90,300							
	91,800							
	92,700	29.2 (1.15)						
	92,750							
	92,900							
	93,500							
	94,800							
	95,000							
	95,200							
	95,400							
	97,900	30.5 (1.20)						
	103,000							
	103,400							
	103,700	31.8 (1.25)						
	104,749							
	106,649							
	109,329	33.0 (1.30)						
	109,337							
	111,749							
	111,849							
	112,249	34.3 (1.35)						
	115,749							
	116,249	35.6 (1.40)						
4 Hz	117,249							

Panel No. 12C		Primary Crack Lengths millimeters (inches)				Secondary Crack Lengths millimeters (inches)		
Cycle Rate	**No. of Cycles**	**L/H Outside**	**R/H Outside**	**L/H Inside**	**R/H Inside**	L/H Edge Outside	R/H Edge Outside	L/H Edge Inside
4 Hz	117,849	36.8 (1.45)	35.6 (1.40)					
	118,749							
	120,049				24.1 (.95)			24.1 (.95)
	121,149			27.9 (1.10)				
	123,949							
	124,349							25.4 (1.00)
	126,949			29.2 (1.15)	25.4 (1.00)			
	129,049	38.1 (1.50)	36.8 (1.45)				25.4 (1.00)	
	130,849							26.7 (1.05)
	131,049							
	133,649			30.5 (1.20)	26.7 (1.05)			
	133,749	39.4 (1.55)	38.1 (1.50)			36.8 (1.45)		
	133,849							27.9 (1.10)
	134,549							
	136,749					38.1 (1.50)		
	137,349	40.6 (1.60)	39.4 (1.55)					
	137,749						27.9 (1.10)	
	140,749	41.9 (1.65)						30.5 (1.20)
	141,349			31.8 (1.25)	27.9 (1.10)			
	141,749							
	143,549					39.4 (1.55)	29.2 (1.15)	
	144,049		40.6 (1.60)					
	145,749							31.8 (1.25)
	146,449			33.0 (1.30)	30.5 (1.20)			
	146,549							
	148,249	43.2 (1.70)	41.9 (1.65)				30.5 (1.20)	
	148,749					41.9 (1.65)		
	149,649							33.0 (1.30)
	152,049			34.3 (1.35)	31.8 (1.25)			
	152,349							
	153,049	44.4 (1.75)	43.2 (1.70)				31.8 (1.25)	
4 Hz	155,885				34.3 (1.35)			

Panel No.12C		Secondary Crack Lengths millimeters (inches)					
Cycle Rate	No. of Cycles	R/H Edge Inside					
4 Hz	117,849						
	118,749	36.8 (1.45)					
	120,049						
	121,149						
	123,949	38.1 (1.50)					
	124,349						
	126,949						
	129,049						
	130,849						
	131,049	39.4 (1.55)					
	133,649						
	133,749						
	133,849						
	134,549	40.6 (1.60)					
	136,749						
	137,349						
	137,749						
	140,749						
	141,349						
	141,749	41.9 (1.65)					
	143,549						
	144,049						
	145,749						
	146,449						
	146,549	43.2 (1.70)					
	148,249						
	148,749						
	149,649						
	152,049						
	152,349	44.4 (1.75)					
	153,049						
4 Hz	155,885						

Panel No. 12C		Primary Crack Lengths millimeters (inches)				Secondary Crack Lengths millimeters (inches)		
Cycle Rate	No. of Cycles	L/H Outside	R/H Outside	L/H Inside	R/H Inside	L/H Edge Outside	R/H Edge Outside	L/H Edge Inside
4 Hz	157,185	45.7 (1.80)	44.4 (1.75)				33.0 (1.30)	
	157,685					43.2 (1.70)		
	161,885	47.0 (1.85)	45.7 (1.80)					
	163,285						35.6 (1.40)	
	164,685							
	164,885							38.1 (1.50)
	168,885	49.5 (1.95)	48.3 (1.90)					
	169,885						38.1 (1.50)	
	170,785					48.3 (1.90)		
	173,885	50.8 (2.00)	49.5 (1.95)			49.5 (1.95)	39.4 (1.55)	
	176,685							39.4 (1.55)
	178,285	52.1 (2.05)	50.8 (2.00)					
	179,085						41.9 (1.65)	
	179,385	53.3 (2.10)						
	179,885		52.1 (2.05)			50.8 (2.00)		
	183,885	54.6 (2.15)	53.3 (2.10)			52.1 (2.05)	43.2 (1.70)	
	184,585				36.8 (1.45)			41.9 (1.65)
	186,585						44.4 (1.75)	
	186,885	55.9 (2.20)	54.6 (2.15)			53.3 (2.10)		
	187,885				38.1 (1.50)			43.2 (1.70)
	188,285			38.1 (1.50)				
	195,385			39.4 (1.55)	40.6 (1.60)			
	198,285		55.9 (2.20)					
	198,685						45.7 (1.80)	
	199,985					54.6 (2.15)		
	203,185	58.4 (2.30)	57.2 (2.25)					
	204,085				41.9 (1.65)			
	204,485			40.6 (1.60)				
	207,785	59.7 (2.35)	58.4 (2.30)					
	207,985							
	208,185					57.2 (2.25)		
4 Hz	208,485							

Panel No. 12C		Secondary Crack Lengths millimeters (inches)						
Cycle Rate	No. of Cycles	R/H Edge Inside						
4 Hz	157,185							
	157,685							
	161,885							
	163,285							
	164,685	45.7 (1.80)						
	164,885							
	168,885							
	169,885							
	170,785							
	173,885							
	176,685							
	178,285							
	179,085							
	179,385							
	179,885							
	183,885							
	184,585							
	186,585							
	186,885							
	187,885							
	188,285							
	195,385							
	198,285							
	198,685							
	199,985							
	203,185							
	204,085							
	204,485							
	207,785	57.2 (2.25)						
	207,985	58.4 (2.30)						
	208,185	59.7 (2.35)						
4 Hz	208,485	61.0 (2.40)						

Panel No. 12C		Primary Crack Lengths millimeters (inches)				Secondary Crack Lengths millimeters (inches)		
Cycle Rate	No. of Cycles	L/H Outside	R/H Outside	L/H Inside	R/H Inside	L/H Edge Outside	R/H Edge Outside	L/H Edge Inside
4 Hz	208,585						49.5 (1.95)	
	208,885							
	209,085				43.2 (1.70)			
	209,585							
	210,785							
	211,485			41.9 (1.65)				
	212,435							
	212,885	61.0 (2.40)						
	213,385							
	213,685						50.8 (2.00)	
	214,785					58.4 (2.30)		
	215,185		59.7 (2.35)					
	216,885							
	217,685				44.4 (1.75)			
	218,885			43.2 (1.70)				
	219,085	62.2 (2.45)	61.0 (2.40)			OVERLAPS L/H		
	219,385	OVERLAPS L/H				OUTSIDE PRI-		
	220,685	OUTSIDE EDGE				MARY CRACK		
	222,985	SECONDARY	62.2 (2.45)					
	223,185	CRACK						
	223,485						53.3 (2.10)	
	223,585				45.7 (1.80)			
	226,085							
	226,185			44.4 (1.75)				
	228,132							
	228,532		63.5 (2.50)			63.5 (2.50)		
	228,632	63.5 (2.50)						
	228,832						54.6 (2.15)	
	229,432							
	231,832							
	232,832		64.8 (2.55)	45.7 (1.80)				
4 Hz	233,032					64.8 (2.55)		

Panel No. 12C		Secondary Crack Lengths millimeters (inches)					
Cycle Rate	No. of Cycles	R/H Edge Inside					
4 Hz	208,585						
	208,885	62.2 (2.45)					
	209,085						
	209,585	63.5 (2.50)					
	210,785	64.8 (2.55)					
	211,485						
	212,435	66.0 (2.60)					
	212,885						
	213,385	67.3 (2.65)					
	213,685						
	214,785	68.6 (2.70)					
	215,185						
	216,885	69.8 (2.75)					
	217,685						
	218,885	71.1 (2.80)					
	219,085						
	219,385						
	220,685	72.4 (2.85)					
	222,985						
	223,185	73.7 (2.90)					
	223,485						
	223,585						
	226,085	74.9 (2.95)					
	226,185						
	228,132	76.2 (3.00)					
	228,532						
	228,632						
	228,832						
	229,432	77.5 (3.05)					
	231,832	78.7 (3.10)					
	232,832						
4 Hz	233,032						

Panel No. 12C		Primary Crack Lengths millimeters (inches)				Secondary Crack Lengths millimeters (inches)		
Cycle Rate	**No. of Cycles**	**L/H Outside**	**R/H Outside**	**L/H Inside**	**R/H Inside**	L/H Edge Outside	R/H Edge Outside	L/H Edge Inside
4 Hz	233,732	64.8 (2.55)						
	234,432							
	235,832		← OVERLAPS R/H				55.9 (2.20)	
	237,432		OUTSIDE EDGE		48.3 (1.90)		OVERLAPS R/H	
	238,032		SECONDARY				OUTSIDE PRI-	
	238,432		CRACK				MARY CRACK	52.1 (2.05)
	238,532			47.0 (1.85)				
	238,832							53.3 (2.10)
	239,282							54.6 (2.15)
	239,332					66.0 (2.60)		
	239,832		67.3 (2.65)					
	240,032							55.9 (2.20)
	240,632							57.2 (2.25)
	240,932							
	241,282							58.4 (2.30)
	241,932							59.7 (2.35)
	242,582							61.0 (2.40)
	243,032							62.2 (2.45)
	243,332						57.2 (2.25)	
	243,432	66.0 (2.60)						
	243,532				49.5 (1.95)			63.5 (2.50)
	244,332							64.8 (2.55)
	244,832							
	245,132							66.0 (2.60)
	245,332			48.3 (1.90)				
	245,632							67.3 (2.65)
	246,132							68.6 (2.70)
	246,632		68.6 (2.70)					
	246,832							69.8 (2.75)
	247,582							71.1 (2.80)
	247,732					67.3 (2.65)		
4 Hz	248,032						58.4 (2.30)	

Panel No. 12C		Secondary Crack Lengths millimeters (inches)						
Cycle Rate	No. of Cycles	R/H Edge Inside						
4 Hz	233,732							
	234,432	80.0 (3.15)						
	235,832							
	237,432							
	238,032	86.3 (3.20)						
	238,432							
	238,532							
	238,832							
	239,282							
	239,332							
	239,832							
	240,032							
	240,632							
	240,932	82.6 (3.25)						
	241,282							
	241,932							
	242,582							
	243,032							
	243,332							
	243,432							
	243,532							
	244,332							
	244,832	83.8 (3.30)						
	245,132							
	245,332							
	245,632							
	246,132							
	246,632							
	246,832							
	247,582							
	247,732							
4 Hz	248,032							

Panel No. 12C		Primary Crack Lengths millimeters (inches)				Secondary Crack Lengths millimeters (inches)		
Cycle Rate	**No. of Cycles**	**L/H Outside**	**R/H Outside**	**L/H Inside**	**R/H Inside**	L/H Edge Outside	R/H Edge Outside	L/H Edge Inside
4 Hz	248,332							72.4 (2.85)
	248,832							
	249,082							73.7 (2.90)
	249,632				50.8 (2.00)			
	250,632							76.2 (3.00)
	250,932			49.5 (1.95)				
	251,332							77.5 (3.05)
	251,432							
	252,332							78.7 (3.10)
4 Hz	252,993	67.3 (2.65)	69.8 (2.75)			68.6 (2.70)	59.7 (2.35)	
FINAL CRACK LENGTHS		67.3 (2.65)	69.8 (2.75)	49.5 (1.95)	50.8 (2.00)	68.6 (2.70)	59.7 (2.35)	78.7 (3.10)

RESIDUAL STRENGTH = 253,500 N (57,000 lbs.)

Panel No. 12C		Secondary Crack Lengths millimeters (inches)						
Cycle Rate	No. of Cycles	R/H Edge Inside						
4 Hz	248,332							
	248,832	85.1 (3.35)						
	249,082							
	249,632							
	250,632							
	250,932							
	251,332							
	251,432	86.4 (3.40)						
	252,332							
4 Hz	252,993							
FINAL CRACK LENGTH		86.4 (3.40)						

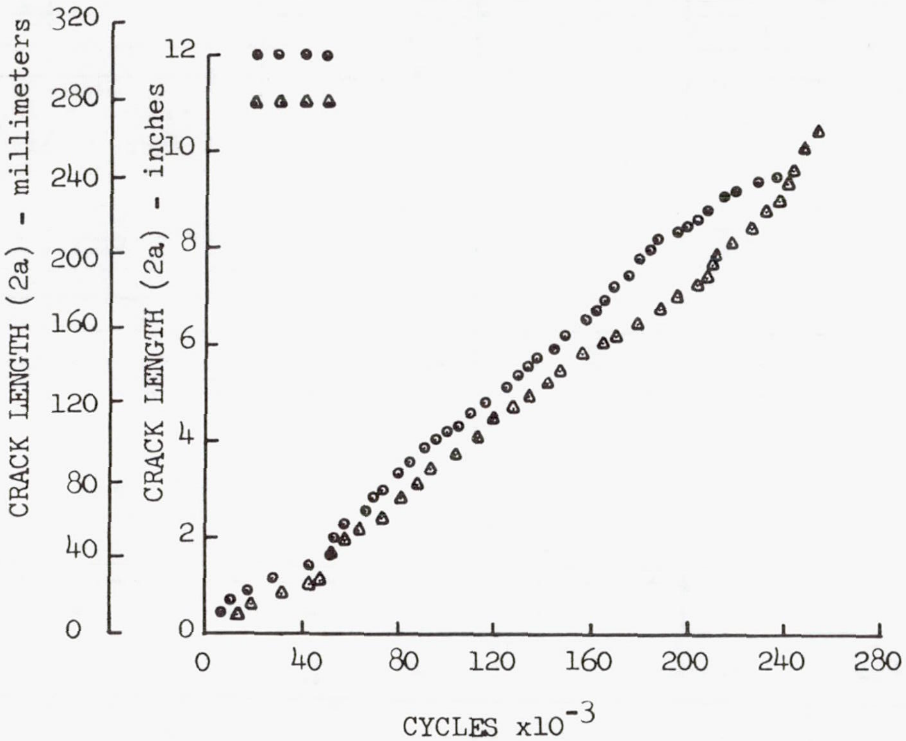

FIGURE F-49 CRACK GROWTH CURVE FOR ALUMINUM-GRAPHITE PANEL #12C
(Crack Length Includes Secondary Cracks)

PANEL #13C

MATERIALS: ALUMINUM-GRAPHITE

ADHESIVE: EA-927R

ALUMINUM STRESS: 103 MN/m^2 (15 ksi)

MAXIMUM FATIGUE LOAD: 124,540N (28,000 lbf)

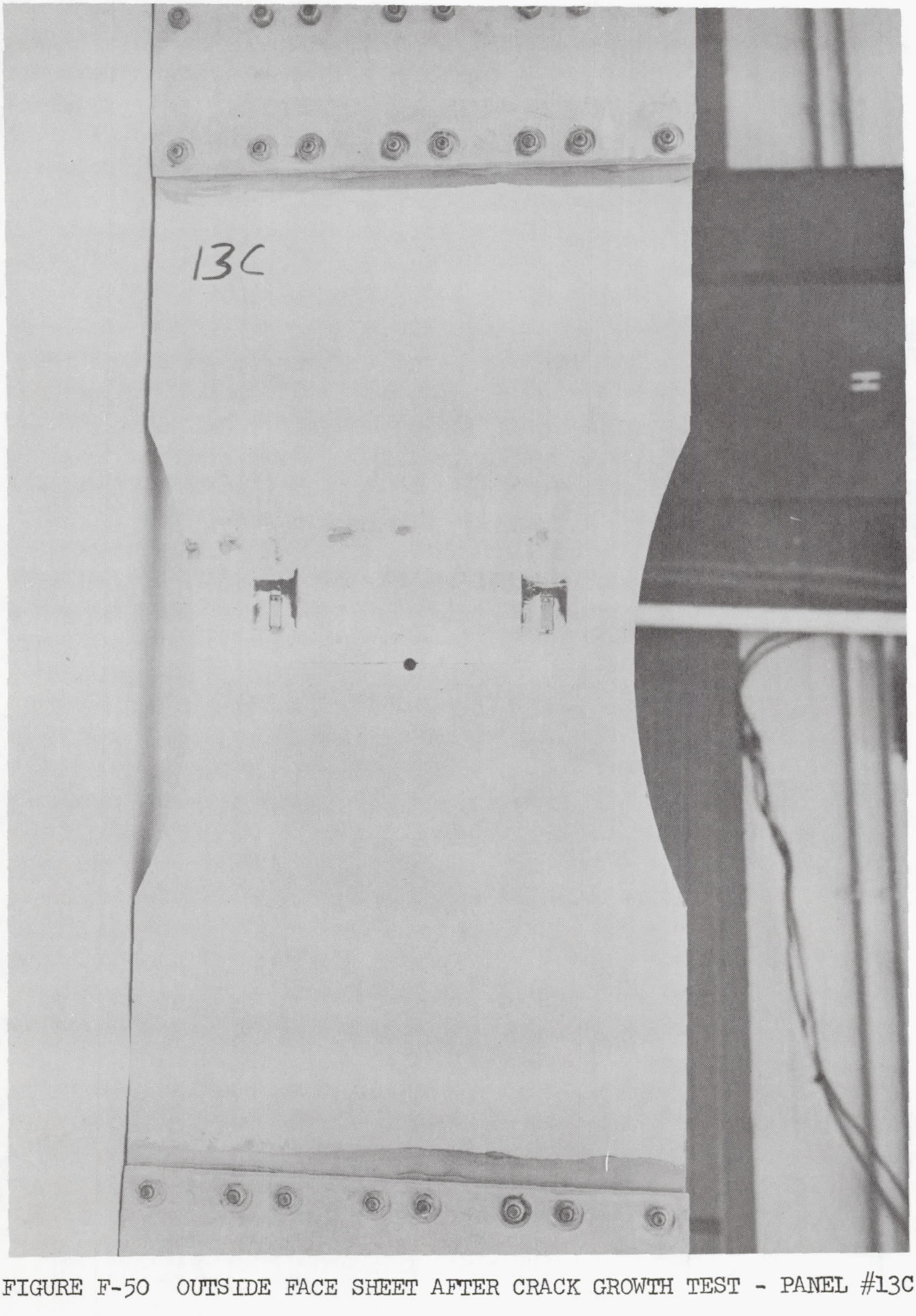

FIGURE F-50 OUTSIDE FACE SHEET AFTER CRACK GROWTH TEST - PANEL #13C

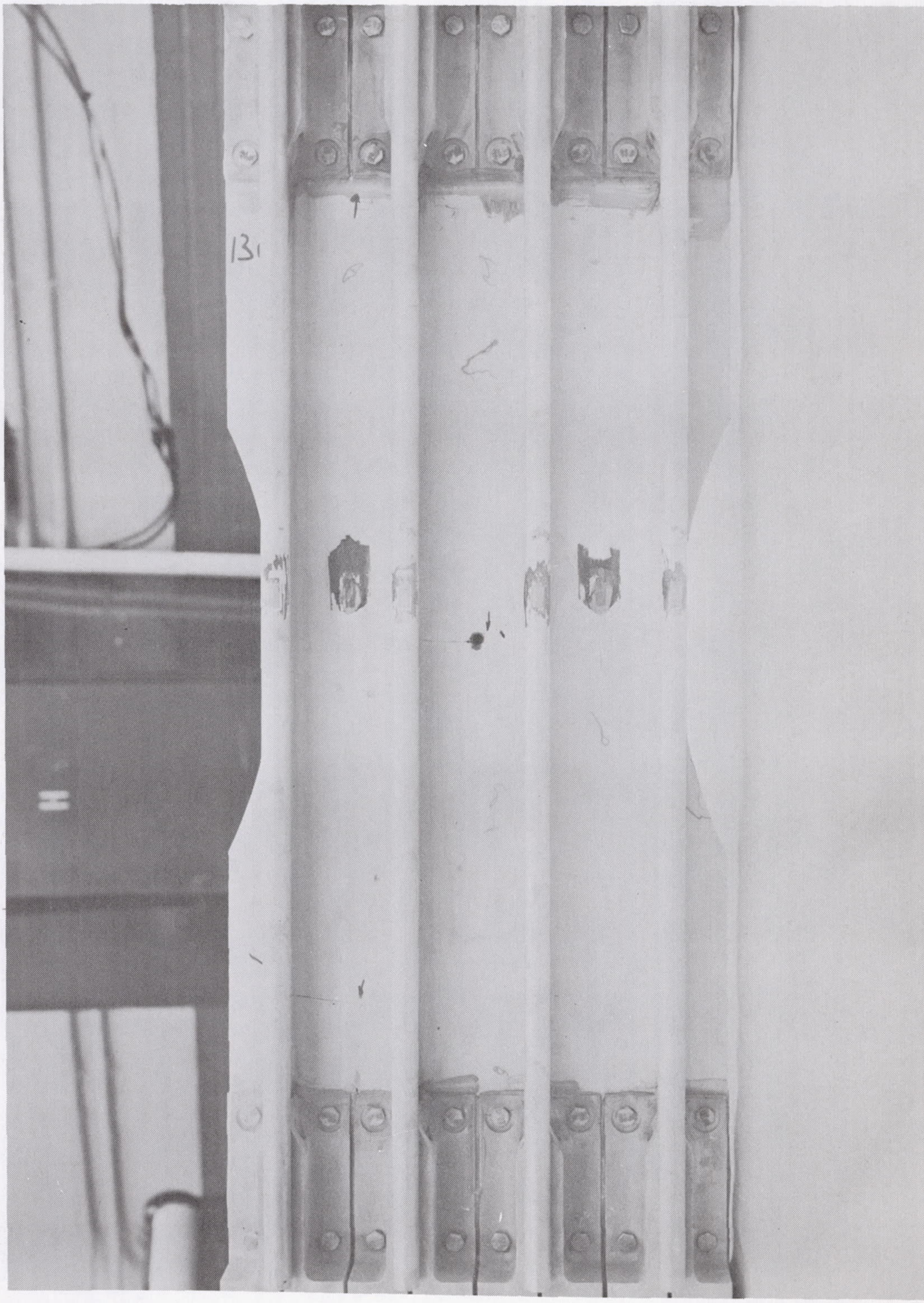

FIGURE F-51 INSIDE STIFFENER SHEET AFTER CRACK GROWTH TEST - PANEL #13C

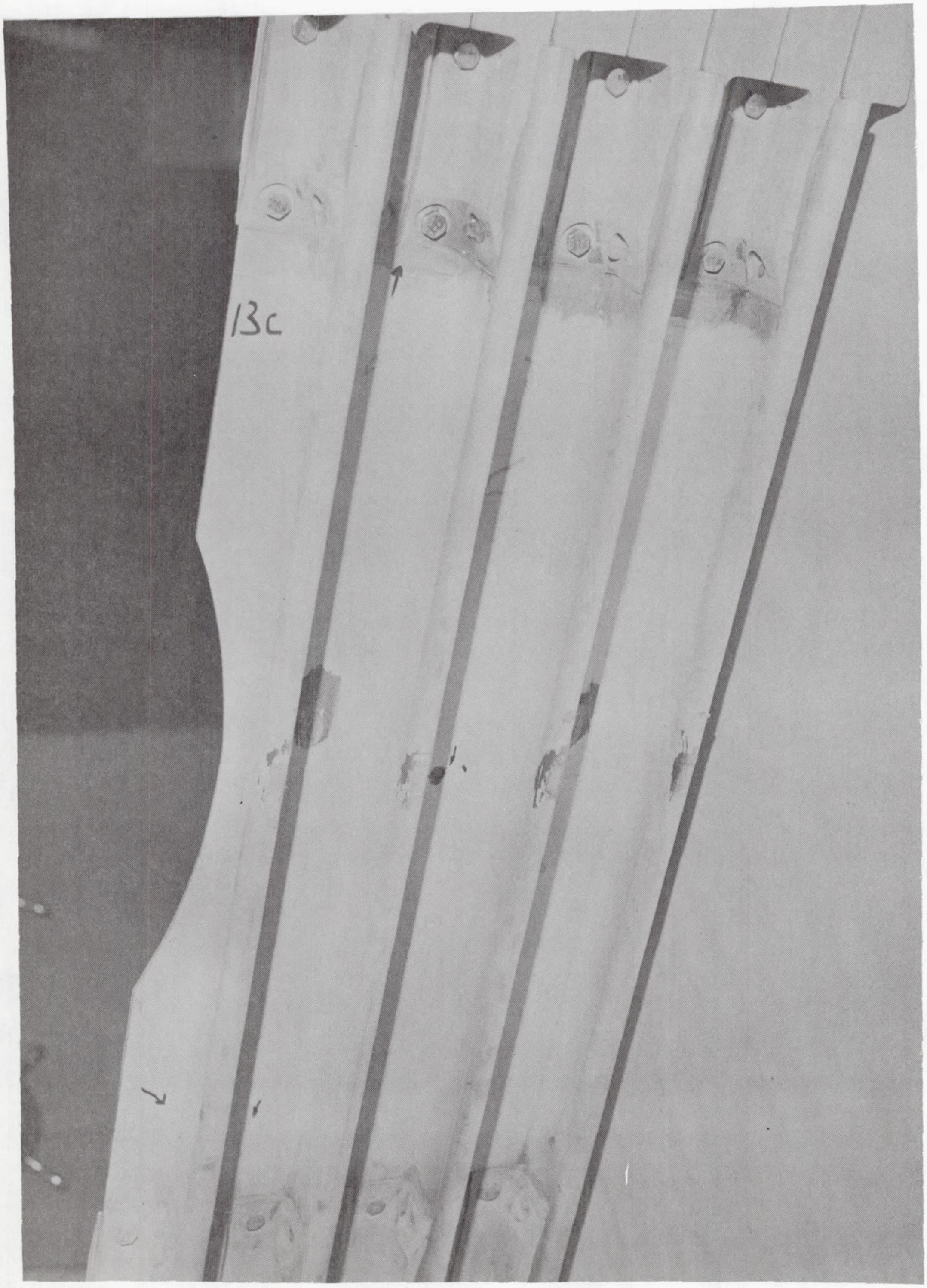

FIGURE F-52 INSIDE STIFFENER SHEET AFTER CRACK GROWTH TEST - PANEL #13C

(LEFT OF CENTERLINE)

Panel No. 13C		Primary Crack Lengths millimeters (inches)				Secondary Crack Lengths millimeters (inches)		
Cycle Rate	No. of Cycles	L/H Outside	R/H Outside	L/H Inside	R/H Inside			
4Hz	24,700	5.1 (.20)						
	28,800	6.4 (.25)						
	32,300		3.8 (.15)					
	34,450		5.1 (.20)					
	36,200	7.6 (.30)						
	44,300		6.4 (.25)					
	45,700	8.9 (.35)						
4Hz	54,300	10.2 (.40)	7.6 (.30)					
5Hz	60,090		8.9 (.35)					
	69,660	11.4 (.45)						
	79,260	12.7 (.50)						
5Hz	81,160		10.2 (.40)					
6Hz	92,460	14.0 (.55)						
	93,560		11.4 (.45)					
	103,160	15.2 (.60)						
	104,460		12.7 (.50)					
	114,760	16.5 (.65)						
6Hz	115,360		14.0 (.55)					
8Hz	127,550		15.2 (.60)					
	135,150	17.8 (.70)						
	152,250		16.5 (.65)					
	158,250	19.0 (.75)		5.1 (.20)				
	170,650		17.8 (.70)					
	170,950	20.3 (.80)						
	175,150	21.6 (.85)	19.0 (.75)					
	186,764			7.6 (.30)				
	196,350	22.9 (.90)	20.3 (.80)					
	207,850	24.1 (.95)						
	208,250			8.9 (.35)				
	217,650		21.6 (.85)					
	224,750			10.2 (.40)				
8Hz	225,350	25.4 (1.00)						

Panel No. 13C		Primary Crack Lengths millimeters (inches)				Secondary Crack Lengths millimeters (inches)		
Cycle Rate	No. of Cycles	L/H Outside	R/H Outside	L/H Inside	R/H Inside			
8Hz	233,550	26.7 (1.05)						
	236,150		22.9 (.90)					
	253,091	27.9 (1.10)						
	256,491		24.1 (.95)					
	256,691			11.4 (.45)				
	269,691	29.2 (1.15)	25.4 (1.00)					
	282,491			12.7 (.50)				
	283,891	30.5 (1.20)						
	294,591		26.7 (1.05)					
	295,691	31.8 (1.25)						
	308,391	33.0 (1.30)	27.9 (1.10)					
	320,991	34.3 (1.35)						
	333,064		29.2 (1.15)	14.0 (.55)	6.4 (.25)			
	348,791		30.5 (1.20)					
	348,891	35.6 (1.40)						
	361,791	36.8 (1.45)						
	369,821			15.2 (.60)	7.6 (.30)			
	375,601		31.8 (1.25)					
	381,521				8.9 (.35)			
	414,521	38.1 (1.50)						
	414,621		33.0 (1.30)					
	432,761	39.4 (1.55)	34.3 (1.35)	16.5 (.65)				
	449,121	40.6 (1.60)						
	458,021		35.6 (1.40)					
	495,821	41.9 (1.65)	36.8 (1.45)					
	516,798	43.2 (1.70)	38.1 (1.50)	17.8 (.70)				
	535,098		39.4 (1.55)					
	551,898	44.4 (1.75)						
	562,798		40.6 (1.60)					
	578,898		41.9 (1.65)					
	586,198	45.7 (1.80)						
8Hz	592,798	47.0 (1.85)	43.2 (1.70)					

Panel No. 13C		Primary Crack Lengths millimeters (inches)				Secondary Crack Lengths millimeters (inches)		
Cycle Rate	No. of Cycles	L/H Outside	R/H Outside	L/H Inside	R/H Inside			
8Hz	615,398		44.4 (1.75)	19.0 (.75)				
	629,998	48.3 (1.90)						
	630,098		45.7 (1.80)					
	649,380	49.5 (1.95)	47.0 (1.85)					
	671,380	50.8 (2.00)	48.3 (1.90)					
	686,380		49.5 (1.95)					
	689,380	52.1 (2.05)						
	701,380		50.8 (2.00)					
	708,940	53.3 (2.10)		20.3 (.80)				
	720,180		52.1 (2.05)					
	732,080		53.3 (2.10)					
	734,680	54.6 (2.15)	54.6 (2.15)					
	750,280			21.6 (.85)				
	761,480	55.9 (2.20)	55.9 (2.20)					
	783,180		57.2 (2.25)					
	791,980	57.2 (2.25)						
	803,080	58.4 (2.30)	58.4 (2.30)					
	820,280	59.7 (2.35)	59.7 (2.35)					
	841,580	61.0 (2.40)	61.0 (2.40)					
	859,080		62.2 (2.45)					
	860,080	62.2 (2.45)						
	863,160			22.9 (.90)				
	872,780		63.5 (2.50)					
	875,780	63.5 (2.50)						
	885,780		64.8 (2.55)					
	895,480	64.8 (2.55)						
	903,980		66.0 (2.60)					
	914,880		67.3 (2.65)					
	924,780	66.0 (2.60)						
	931,580		68.6 (2.70)					
	942,580	67.3 (2.65)						
8Hz	950,032		69.8 (2.75)					

Panel No. 13C		Primary Crack Lengths millimeters (inches)				Secondary Crack Lengths millimeters (inches)		
Cycle Rate	No. of Cycles	L/H Outside	R/H Outside	L/H Inside	R/H Inside			
8Hz	964,532	68.6 (2.70)						
	965,032		71.1 (2.80)					
	968,732	69.8 (2.75)						
	987,832	71.1 (2.80)	72.4 (2.85)					
	1,000,032		73.7 (2.90)					
	1,005,345			24.1 (.95)				
	1,005,346	72.4 (2.85)						
	1,019,532			25.4 (1.00)	10.2 (.40)			
	1,020,032		74.9 (2.95)					
	1,030,032	73.7 (2.90)						
	1,037,422	74.9 (2.95)	76.2 (3.00)					
	1,065,032	76.2 (3.00)	77.5 (3.05)					
	1,073,473		78.7 (3.10)	26.7 (1.05)				
	1,083,873	77.5 (3.05)						
	1,092,879		80.0 (3.15)					
	1,116,223		81.3 (3.20)					
	1,123,543	78.7 (3.10)						
	1,143,473	80.0 (3.15)	82.6 (3.25)					
	1,169,723	81.3 (3.20)						
	1,170,406		83.8 (3.30)					
	1,184,906	82.6 (3.25)	85.1 (3.35)					
	1,206,956				12.7 (.50)			
	1,215,456	83.8 (3.30)	87.6 (3.45)					
	1,217,236				14.0 (.55)			
	1,227,756	85.1 (3.35)	88.9 (3.50)					
	1,229,936				15.2 (.60)			
	1,248,906	86.4 (3.40)	90.2 (3.55)					
	1,256,266	87.6 (3.45)	91.4 (3.60)					
	1,288,286	88.9 (3.50)	92.7 (3.65)					
	1,308,506	90.2 (3.55)	94.0 (3.70)					
	1,315,136	91.4 (3.60)	95.2 (3.75)					
8Hz	1,326,806	92.7 (3.65)	96.5 (3.80)					

Panel No. 13C		Primary Crack Lengths millimeters (inches)				Secondary Crack Lengths millimeters (inches)		
Cycle Rate	No. of Cycles	L/H Outside	R/H Outside	L/H Inside	R/H Inside			
8Hz	1,343,608	94.0 (3.70)	97.8 (3.85)					
↑	1,363,008	95.2 (3.75)	99.1 (3.90)					
	1,372,408	96.5 (3.80)	100.3 (3.95)					
	1,407,908	100.3 (3.95)	101.6 (4.00)	27.9 (1.10)				
	1,415,908	101.6 (4.00)	104.1 (4.10)					
	1,422,408	102.9 (4.05)	105.4 (4.15)					
	1,430,308	104.1 (4.10)	106.7 (4,20)					
	1,430,408			29.2 (1.15)				
	1,439,408	105.4 (4.15)	108.0 (4.25)					
	1,452,408	106.7 (4.20)	109.2 (4.30)					
	1,462,408	108.0 (4.25)	110.5 (4.35)					
	1,473,408	109.2 (4.30)	111.8 (4.40)					
	1,488,408	110.5 (4.35)	113.0 (4.45)					
	1,498,708	111.8 (4.40)	114.3 (4.50)					
	1,509,408	113.0 (4.45)	116.8 (4.60)					
	1,515,408	114.3 (4.50)	118.1 (4.65)					
	1,523,408	115.6 (4.55)	120.6 (4.75)					
	1,532,408	116.8 (4.60)	121.9 (4.80)					
	1,536,408	118.1 (4.65)	123.2 (4.85)					
	1,546,108	119.4 (4.70)	At Edge					
	1,553,408	120.6 (4.75)	of Panel					
↓	1,558,408	121.9 (4.80)						
8Hz	1,853,408	At Edge		36.8 (1.45)				
		of Panel						
FINAL CRACK LENGTH		121.9(4.80)	123.2(4.85)	36.8 (1.45)	15.2 (.60)			
	Residual	Strength =	371,850 N	(83,600 lbs)				

PANEL #14C

MATERIALS: ALUMINUM - GRAPHITE

ADHESIVE: EA-927R

ALUMINUM STRESS: 138 MN/m^2 (20 ksi)

MAXIMUM FATIGUE LOAD: 168,690N (37,925 lbf)

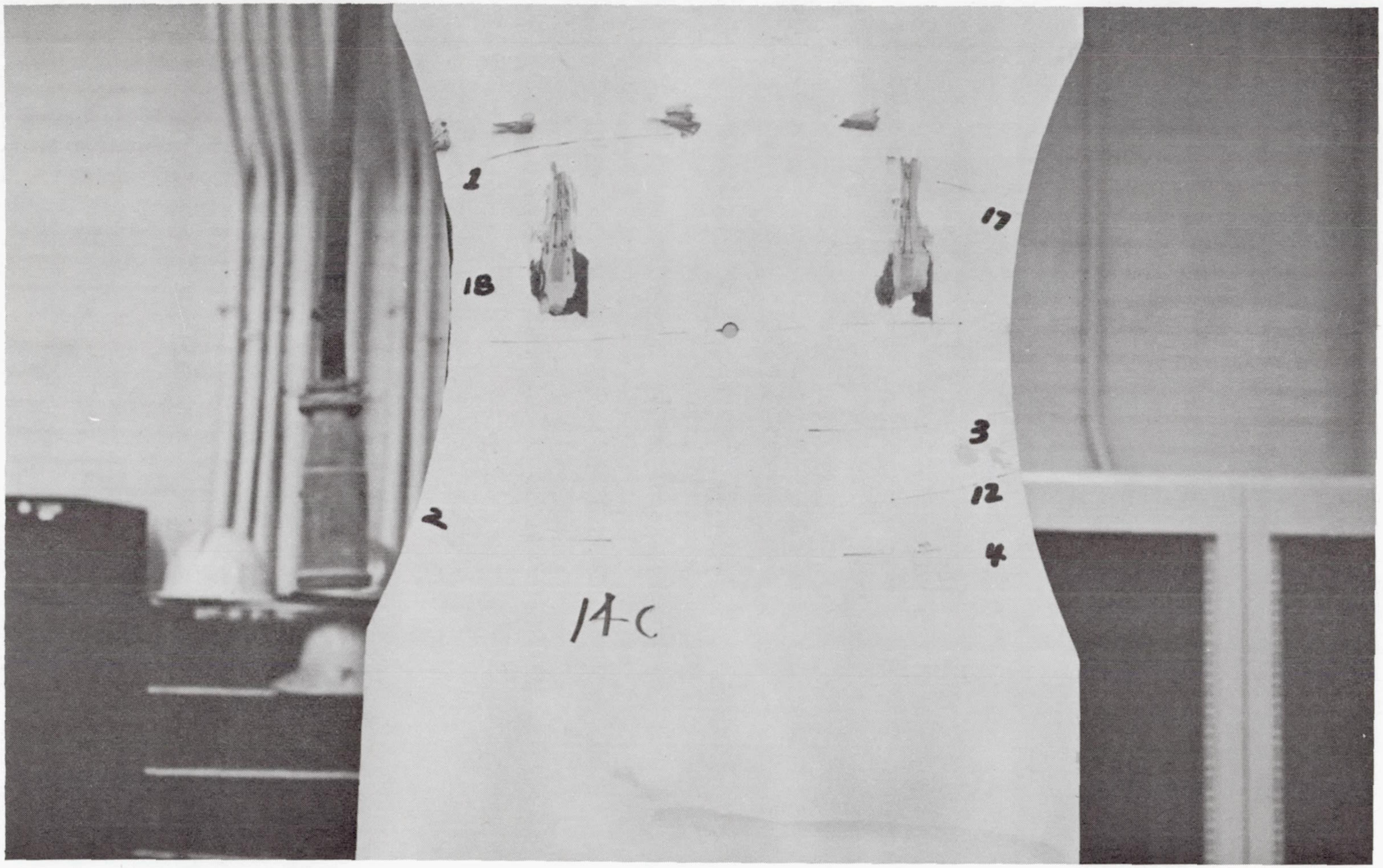

FIGURE F-53 OUTSIDE FACE SHEET AFTER CRACK GROWTH TEST - PANEL #14C

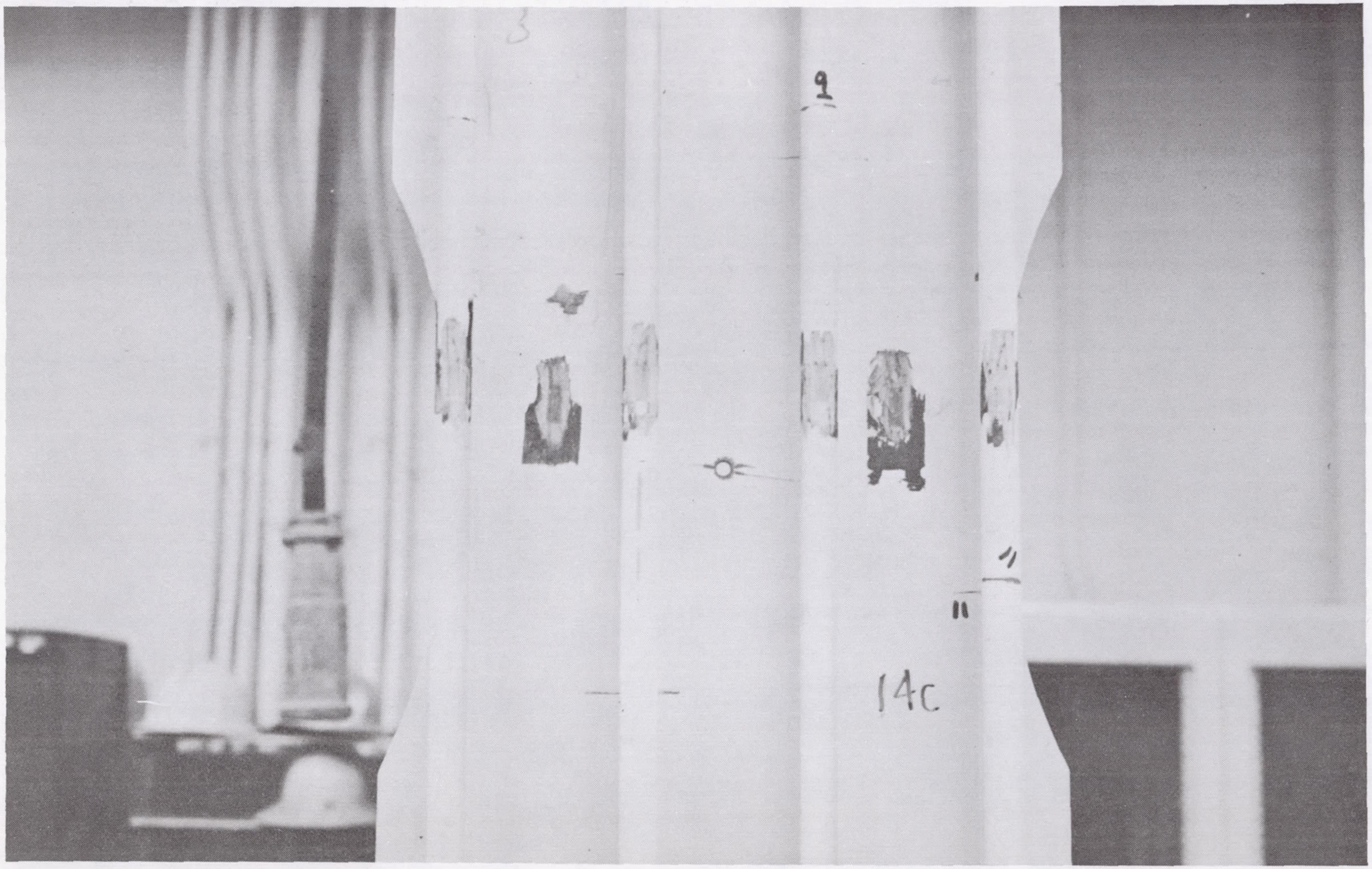

FIGURE F-54 INSIDE STIFFENER SHEET AFTER CRACK GROWTH TEST - PANEL #14C

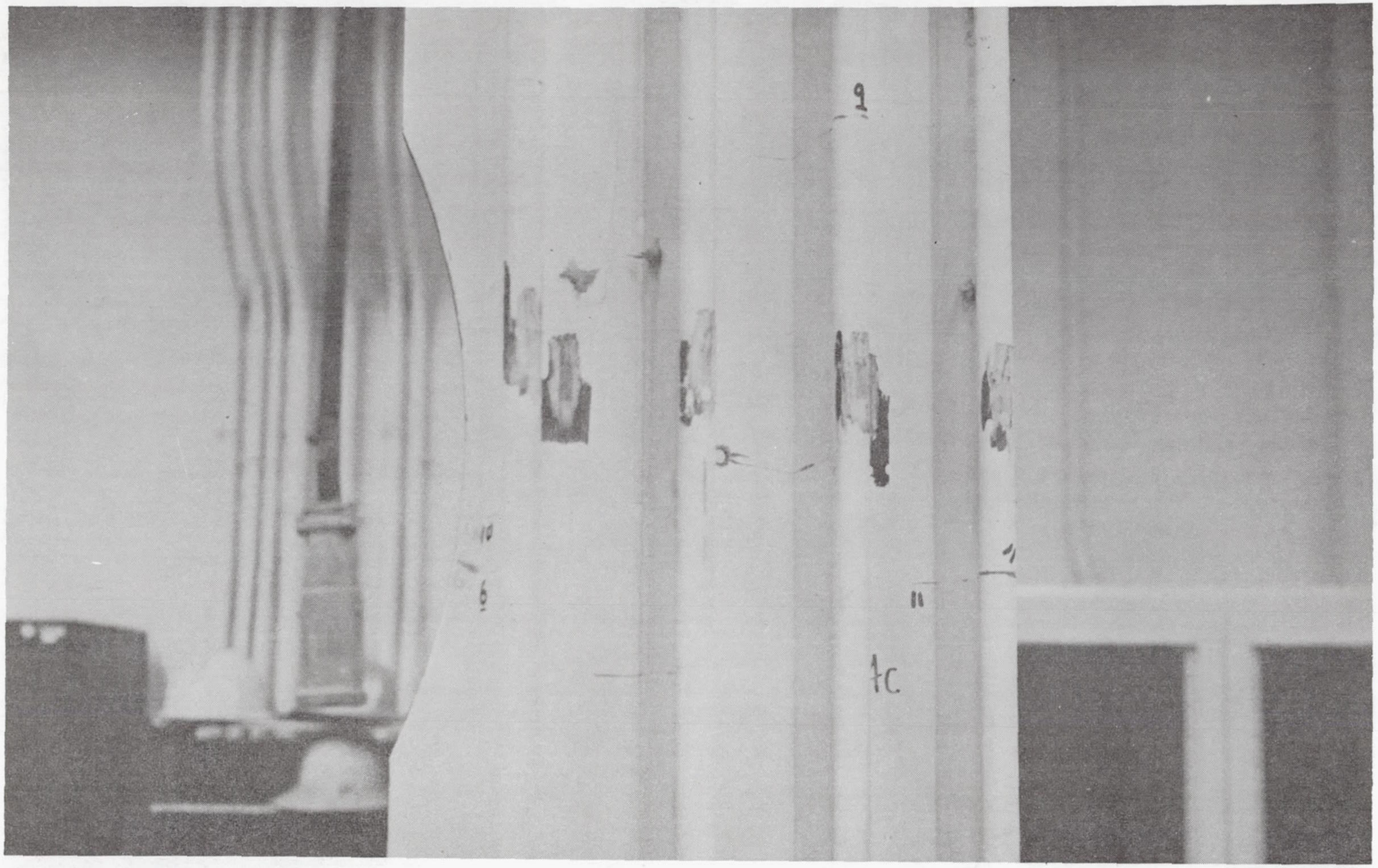

FIGURE F-55 INSIDE STIFFENER SHEET AFTER CRACK GROWTH TEST - PANEL #14C (LEFT OF CENTERLINE)

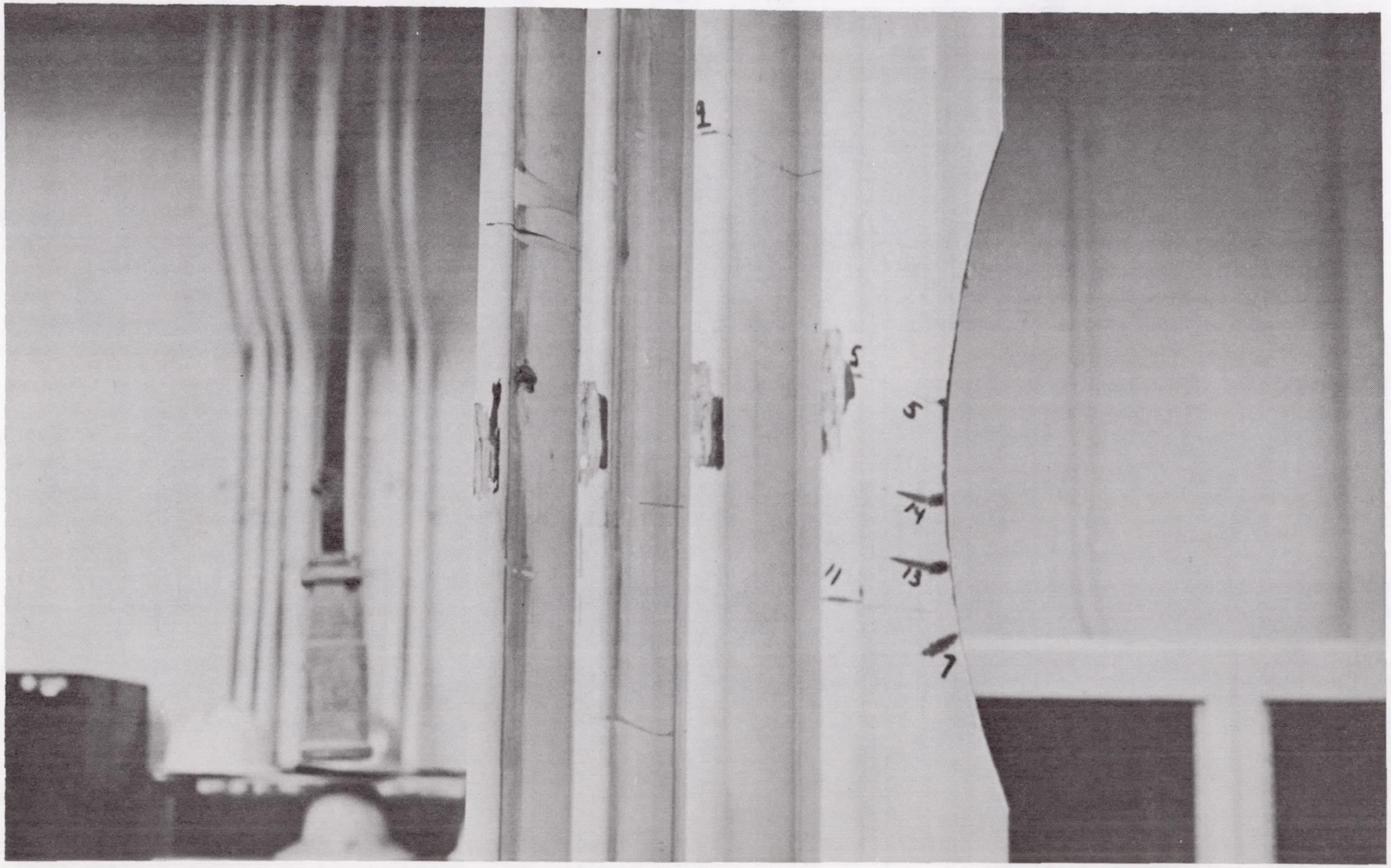

FIGURE F-56 INSIDE STIFFENER SHEET AFTER CRACK GROWTH TEST - PANEL #14C (RIGHT OF CENTERLINE)

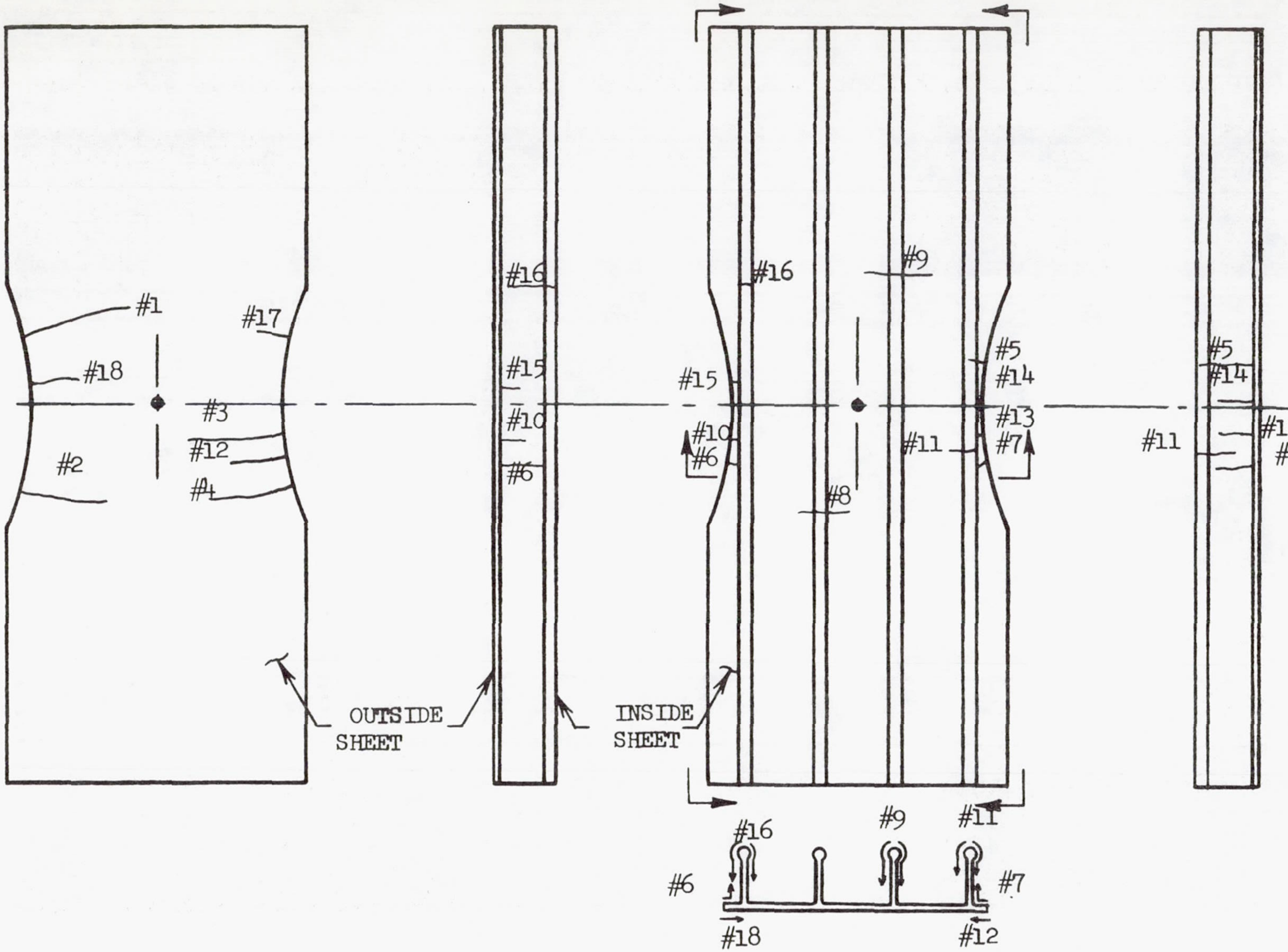

FIGURE F-57 SECONDARY CRACK LOCATIONS
ALUMINUM GRAPHITE PANEL #14C

Panel No. 14C		Primary Crack Lengths millimeters (inches)				Secondary Crack Lengths millimeters (inches)		
Cycle Rate	**No. of Cycles**	**L/H Outside**	**R/H Outside**	**L/H Inside**	**R/H Inside**			
4 Hz	10,000		5.1 (.20)					
↑	13,000	5.1 (.20)						
	14,000		6.4 (.25)					
	17,600	6.4 (.25)	7.6 (.30)					
	23,000	7.6 (.30)	8.9 (.35)					
	27,000			5.1 (.20)				
	27,800	8.9 (.35)						
	28,500		10.2 (.40)					
	33,700			6.4 (.25)				
	35,100	10.2 (.40)	11.5 (.45)					
↓	39,000	11.5 (.45)						
4 Hz	39,953				5.1 (.20)			
5 Hz	41,333		12.7 (.50)					
↑	41,733			7.6 (.30)				
	45,783	12.7 (.50)						
	46,353		14.0 (.55)					
	52,553	14.0 (.55)			6.4 (.25)			
	52,653			8.9 (.35)				
	53,153		15.2 (.60)					
	59,953	15.2 (.60)	16.5 (.65)	10.2 (.40)				
	63,853	16.5 (.65)						
	65,353				7.6 (.30)			
	66,753		17.8 (.70)					
	69,053	17.8 (.70)						
	71,153		19.0 (.75)					
	75,353	19.0 (.75)						
	76,653			11.5 (.45)				
	78,453		20.3 (.80)		8.9 (.35)			
	82,553	20.3 (.80)	21.6 (.85)					
	82,653			12.7 (.50)				
↓	89,753		22.9 (.90)					
5 Hz	89,953	21.6 (.85)						

Panel No. 14C		Primary Crack Lengths millimeters (inches)				Secondary Crack Lengths millimeters (inches)		
Cycle Rate	No. of Cycles	L/H Outside	R/H Outside	L/H Inside	R/H Inside	#3	#5	#6
5 Hz	90,153			14.0 (.55)	10.2 (.40)			
	100,953	22.9 (.90)						
	101,053		24.1 (.95)					
	105,253			15.2 (.60)	11.5 (.45)			
	107,353	24.1 (.95)						
	111,953		25.4 (1.00)					
	114,953	25.4 (1.00)						
	121,853		26.7 (1.05)					
	122,853	26.7 (1.05)						
	126,253			16.5 (.65)	12.7 (.50)			
	126,453		27.9 (1.10)					
	134,253	27.9 (1.10)	29.2 (1.15)					
	134,953				14.0 (.55)			
	135,753			17.8 (.70)				
	137,253	29.2 (1.15)						
	144,647		30.5 (1.20)					
	145,347	30.5 (1.20)						
	150,047				15.2 (.60)			
	151,047			19.0 (.75)				
	151,247	31.8 (1.25)						
	155,047		31.8 (1.25)					
	158,047	33.0 (1.30)						
	160,047		33.0 (1.30)					
	168,547	34.3 (1.35)						
	169,047			20.3 (.80)				
	172,247		34.3 (1.35)					
	180,347					12.7 (.50)		
	180,390			21.6 (.85)	16.5 (.65)		27.9 (1.10)	7.6 (.30)
	180,391	35.6 (1.40)	35.6 (1.40)					
	185,947	36.8 (1.45)	36.8 (1.45)					
	186,047						29.2 (1.15)	
5 Hz	193,047					16.5 (.65)		8.9 (.35)

Panel No. 14C		Primary Crack Lengths millimeters (inches)				Secondary Crack Lengths millimeters (inches)		
Cycle Rate	No. of Cycles	L/H Outside	R/H Outside	L/H Inside	R/H Inside	#3	#5	#6
5 Hz	193,547			22.9 (.90)				
	194,647	38.1 (1.50)						
	195,047		38.1 (1.50)					
	200,047						30.5 (1.20)	
	207,747	39.4 (1.55)	39.4 (1.55)					
	208,547			24.1 (.95)				
	208,647					21.6 (.85)		
	209,747						31.8 (1.25)	
	209,847							10.2 (.40)
	215,647	40.6 (1.60)						
	216,647							12.7 (.50)
	217,847			25.4 (1.00)				
	224,047		40.6 (1.60)					
	229,947	41.9 (1.65)	41.9 (1.65)					
	230,647						33.0 (1.30)	14.0 (.55)
	231,047					25.4 (1.00)		
	234,300				17.8 (.70)			15.2 (.60)
	235,300	43.2 (1.70)	43.2 (1.70)					
	238,100			26.7 (1.05)				
	243,100	44.4 (1.75)	44.4 (1.75)					
	243,500					30.5 (1.20)		
	244,300				19.0 (.75)			
	245,300			27.9 (1.10)				
	246,300						34.3 (1.35)	
	246,800							17.8 (.70)
	254,700	45.7 (1.80)	45.7 (1.80)					
	261,100							19.0 (.75)
	261,300			30.5 (1.20)				
	262,900					35.6 (1.40)		
	264,300				20.3 (.80)		35.6 (1.40)	
	267,300	47.0 (1.85)	47.0 (1.85)					
5 Hz	270,300			31.8 (1.25)				

Panel No. 14C		Primary Crack Lengths millimeters (inches)				Secondary Crack Lengths millimeters (inches)		
Cycle Rate	No. of Cycles	L/H Outside	R/H Outside	L/H Inside	R/H Inside	#3	#5	#6
5 Hz	271,300	48.3 (1.90)	48.3 (1.90)					
	274,800				21.6 (.85)			
	275,800			33.0 (1.30)				
	281,300	49.5 (1.95)	49.5 (1.95)					
	283,100							20.3 (.80)
	283,300			34.3 (1.35)	22.9 (.90)		36.8 (1.45)	
	284,500					39.4 (1.55)		
	288,300		50.8 (2.00)					
	290,100	50.8 (2.00)						
	291,600		52.1 (2.05)	35.6 (1.40)	24.1 (.95)			22.9 (.90)
	294,300	52.1 (2.05)						
	298,700		53.3 (2.10)					
	299,500	53.3 (2.10)						
	305,600	54.6 (2.15)						
	306,500			36.8 (1.45)				
	306,600						39.4 (1.55)	
	306,800				25.4 (1.00)			
	307,300							25.4 (1.00)
	308,700		54.6 (2.15)					
	312,300	55.9 (2.20)						
	316,200		55.9 (2.20)					
	316,800					48.3 (1.90)		
	317,900			38.1 (1.50)				
	320,163	57.2 (2.25)		39.4 (1.55)	26.7 (1.05)			
	323,163							26.7 (1.05)
	323,963	58.4 (2.30)	57.2 (2.25)					
	326,163	59.7 (2.35)						
	326,263			40.6 (1.60)				
	328,163		58.4 (2.30)					
	330,163						40.6 (1.60)	
	330,763	61.0 (2.40)						
5 Hz	331,163					50.8 (2.00)		

Panel No. 14C		Primary Crack Lengths millimeters (inches)				Secondary Crack Lengths millimeters (inches)		
Cycle Rate	No. of Cycles	L/H Outside	R/H Outside	L/H Inside	R/H Inside	#3	#5	#6
5 Hz	333,963		59.7 (2.35)					
	334,963			41.9 (1.65)				
	335,463				27.9 (1.10)			
	338,163	62.2 (2.45)						
	340,163						43.2 (1.70)	
	340,663		61.0 (2.40)					
	344,163	63.5 (2.50)	62.2 (2.45)		29.2 (1.15)			
	344,663						44.4 (1.75)	
	350,163	64.8 (2.55)	63.5 (2.50)				CRACK	
	351,163			43.2 (1.70)			STOPPED	29.2 (1.15)
	352,163				30.5 (1.20)		IN BULB	
	357,163	66.0 (2.60)	64.8 (2.55)				RADIUS	
	357,663				31.8 (1.25)			
	361,282	67.3 (2.65)	OVERLAPS #3	44.4 (1.75)	33.0 (1.30)	57.2 (2.25)		
	367,963	68.6 (2.70)	SECONDARY			OVERLAPS R/H		
	371,463		CRACK		34.3 (1.35)	OUTSIDE PRI-		
	374,563	69.8 (2.75)				MARY CRACK		
	376,663				35.6 (1.40)			
	377,163			45.7 (1.80)				30.5 (1.20)
	378,163	71.1 (2.80)	68.6 (2.70)					
	382,163		69.8 (2.75)					
	383,163	72.4 (2.85)						
	385,163					64.8 (2.55)		
	387,763		71.1 (2.80)					
	390,163	73.7 (2.90)						
	392,163			47.0 (1.85)				
	393,163	74.9 (2.95)						
	394,663				36.8 (1.45)			
	398,963		72.4 (2.85)					
	400,363				38.1 (1.50)			
	401,263	76.2 (3.00)						
5 Hz	401,563		73.7 (2.90)				44.4 (1.75)	

Panel No. 14C		Primary Crack Lengths millimeters (inches)				Secondary Crack Lengths millimeters (inches)		
Cycle Rate	No. of Cycles	L/H Outside	R/H Outside	L/H Inside	R/H Inside	#3	#5	#6
5 Hz	407,763	77.5 (3.05)	74.9 (2.95)				44.4 (1.75)	
	408,176			48.3 (1.90)	39.4 (1.55)	68.6 (2.70)		35.6 (1.40)
	412,176				40.6 (1.60)			
	412,576	78.7 (3.10)						
	414,976				41.9 (1.65)			
	415,776		76.2 (3.00)					
	420,176			49.5 (1.95)				
	423,576		77.5 (3.05)					
	423,726	80.0 (3.15)						
	424,176				43.2 (1.70)			
	424,676							36.8 (1.45)
	425,576					72.4 (2.85)		
	428,176		78.7 (3.10)					
	430,676	81.3 (3.20)						
	431,176				44.4 (1.75)			
	432,176			50.8 (2.00)				
	436,176				45.7 (1.80)			38.1 (1.50)
	437,176		80.0 (3.15)					
	437,676	82.6 (3.25)						
	441,576	83.8 (3.30)	81.3 (3.20)					
	443,076							
	443,351			52.1 (2.05)				39.4 (1.55)
	446,476	85.1 (3.35)						
	446,676							
	446,976		82.6 (3.25)					
	447,176					77.5 (3.05)		
	448,276				47.0 (1.85)			
	450,576	86.4 (3.40)						
	453,076		83.8 (3.30)					
	453,476	87.6 (3.45)						
	454,176							
5 Hz	455,176			53.3 (2.10)			44.4 (1.75)	

Panel No. 14C		Secondary Crack Lengths millimeters (inches)						
Cycle Rate	No. of Cycles	#11	#18					
5 Hz	407,763							
	408,176							
	412,176							
	412,576							
	414,976							
	415,776							
	420,176							
	423,576							
	423,726							
	424,176							
	424,676							
	425,576							
	428,176							
	430,676							
	431,176							
	432,176							
	436,176							
	437,176							
	437,676							
	441,576							
	443,076		14.0 (.55)					
	443,351							
	446,476							
	446,676		15.2 (.60)					
	446,976							
	447,176	44.4 (1.75)						
	448,276							
	450,576							
	453,076							
	453,476							
	454,176		17.8 (.70)					
5 Hz	455,176							

Panel No. 14C		Primary Crack Lengths millimeters (inches)				Secondary Crack Lengths millimeters (inches)		
Cycle Rate	No. of Cycles	L/H Outside	R/H Outside	L/H Inside	R/H Inside	#3	#5	#6
5 Hz	456,176				48.3 (1.90)		44.4 (1.75)	
	459,176							
	459,576		85.1 (3.35)					
	465,076	88.9 (3.50)						
	465,176		86.4 (3.40)					
	465,376				49.5 (1.95)			
	466,476							40.6 (1.60)
	469,376	90.2 (3.55)	87.6 (3.45)	54.6 (2.15)		80.0 (3.15)		
	471,176							
	474,876	91.4 (3.60)						
	477,476							
	478,576		88.9 (3.50)					
	479,176	92.7 (3.65)						
	479,776				50.8 (2.00)			
	480,676			55.9 (2.20)				
	484,176							
	485,476	94.0 (3.70)	90.2 (3.55)					
	487,676				52.1 (2.05)			
	488,176							
	488,376		91.4 (3.60)					
	492,976	95.2 (3.75)						
	494,476	OVERLAPS #18	92.7 (3.65)					
	494,776	SECONDARY						
	499,368	CRACK	94.0 (3.70)	57.2 (2.25)		83.8 (3.30)		41.9 (1.65)
	505,268	97.8 (3.85)	95.2 (3.75)	58.4 (2.30)	53.3 (2.10)			
	510,368	99.1 (3.90)				86.4 (3.40)		
	512,368		96.5 (3.80)					
	516,368	100.3 (3.95)						
	517,768		97.8 (3.85)					
	517,868			59.7 (2.35)	54.6 (2.15)			44.4 (1.75)
	519,368							
5 Hz	523,268	101.6 (4.00)	99.1 (3.90)				44.4 (1.75)	

Panel No. 14C		Secondary Crack Lengths millimeters (inches)						
Cycle Rate	No. of Cycles	#11	#18					
5 Hz	456,176							
	459,176	45.7 (1.80)						
	459,576							
	465,076							
	465,176		19.0 (.75)					
	465,376							
	466,476							
	469,376	47.0 (1.85)						
	471,176		20.3 (.80)					
	474,876							
	477,476		21.6 (.85)					
	478,576							
	479,176							
	479,776							
	480,676							
	484,176		24.1 (.95)					
	485,476							
	487,676							
	488,176		24.5 (1.00)					
	488,376							
	492,976		OVERLAPS L/H					
	494,476		OUTSIDE PRI-					
	494,776	49.5 (1.95)	MARY CRACK					
	499,368	50.8 (2.00)						
	505,268		30.5 (1.20)					
	510,368							
	512,368							
	516,368							
	517,768							
	517,868	53.3 (2.10)						
	519,368		31.8 (1.25)					
5 Hz	523,268							

Panel No. 14C		Primary Crack Lengths millimeters (inches)				Secondary Crack Lengths millimeters (inches)		
Cycle Rate	No. of Cycles	L/H Outside	R/H Outside	L/H Inside	R/H Inside	#3	#5	#6
5 Hz	526,568	102.5 (4.05)					44.4 (1.75)	
	526,868							
	527,068				55.9 (2.20)			
	527,368			61.0 (2.40)				45.7 (1.80)
5 Hz	530,897		100.3 (3.95)	62.2 (2.45)	57.2 (2.25)	88.9 (3.50)	44.4 (1.75)	
FINAL CRACK LENGTHS		102.5 (4.05)	100.3 (3.95)	62.2 (2.45)	57.2 (2.25)	88.9 (3.50)	44.4 (1.75)	45.7 (1.80)
	RESIDUAL STRENGTH		= 279,300	N (62,800	lbs.)			

Panel No. 14C		Secondary Crack Lengths millimeters (inches)						
Cycle Rate	No. of Cycles	#11	#18					
5 Hz	526,568							
	526,868		33.0 (1.30)					
	527,068							
	527,368	54.6 (2.15)						
5 Hz	530,897		34.3 (1.35)					
FINAL CRACK LENGTHS		54.6 (2.15)	34.3 (1.35)					

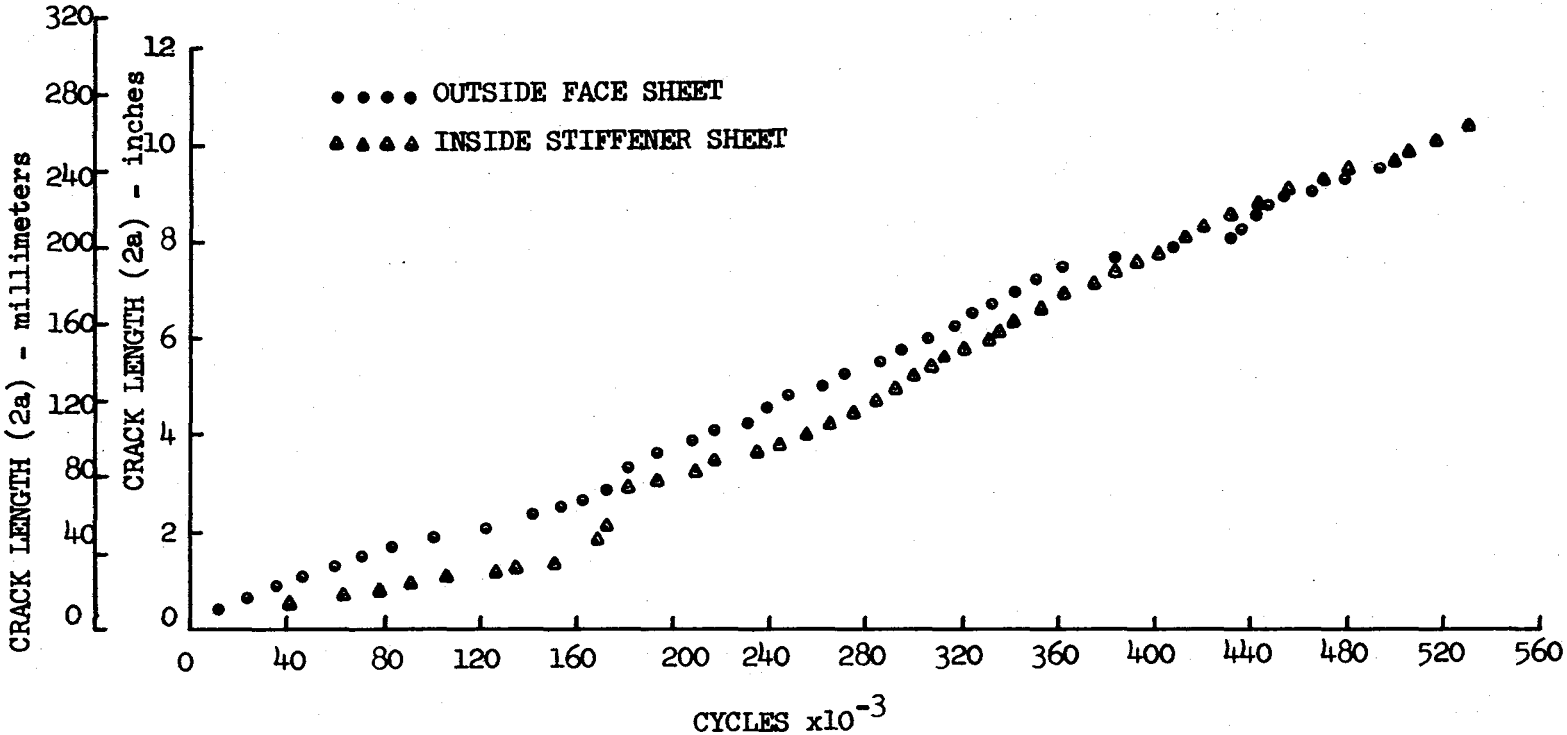

FIGURE F-58 CRACK GROWTH CURVE FOR ALUMINUM-GRAPHITE PANEL #14C
(Crack Length Includes Secondary Cracks)

PANEL #15C

MATERIALS: ALUMINUM-GRAPHITE

ADHESIVE: EA-927R

ALUMINUM STRESS: 116 MN/m^2 (16.9 ksi)

MAXIMUM FATIGUE LOAD: 144,560N (32,500 lbf)

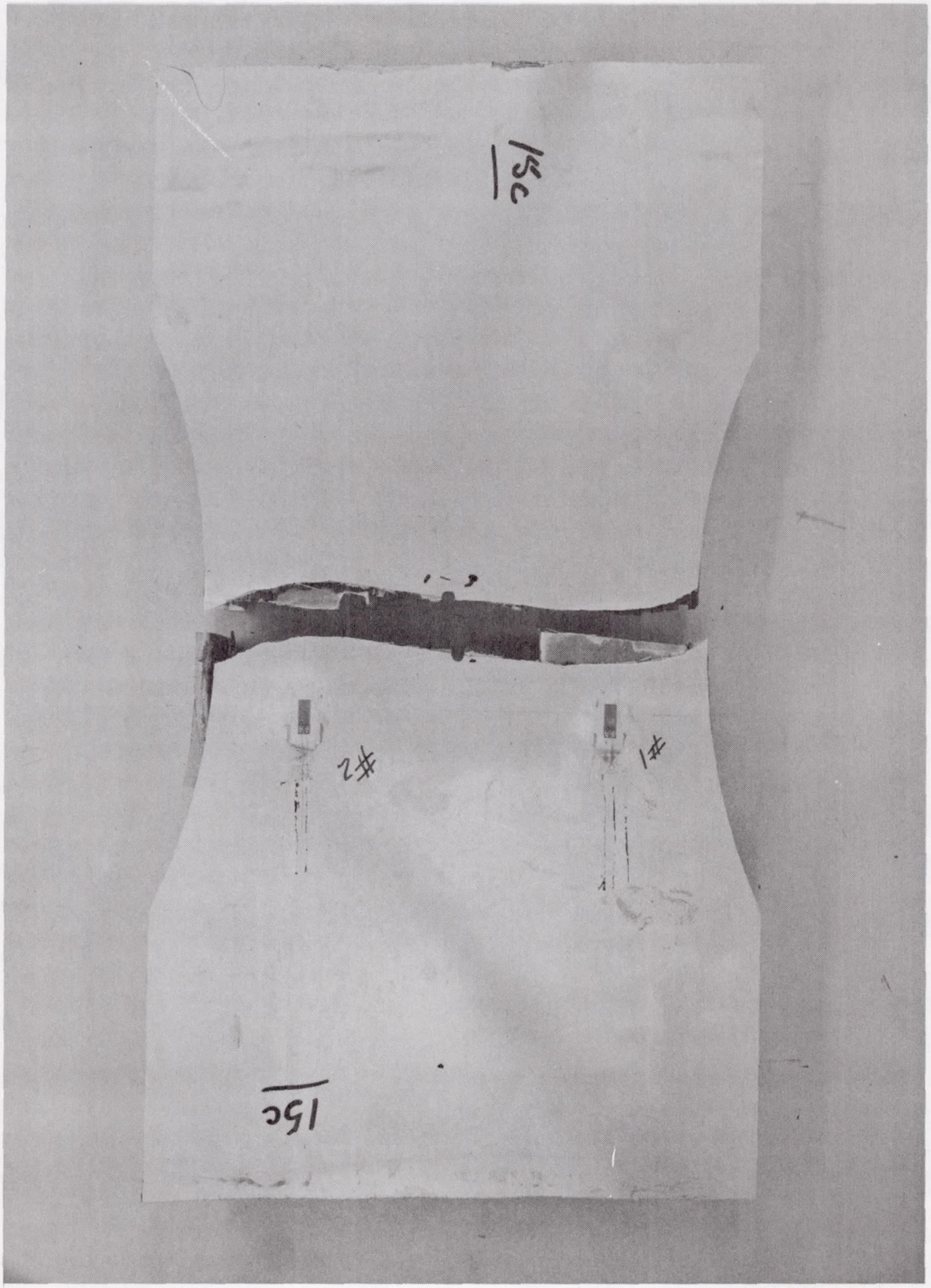

FIGURE F-59 OUTSIDE FACE SHEET AFTER RESIDUAL STRENGTH TEST - PANEL #15C

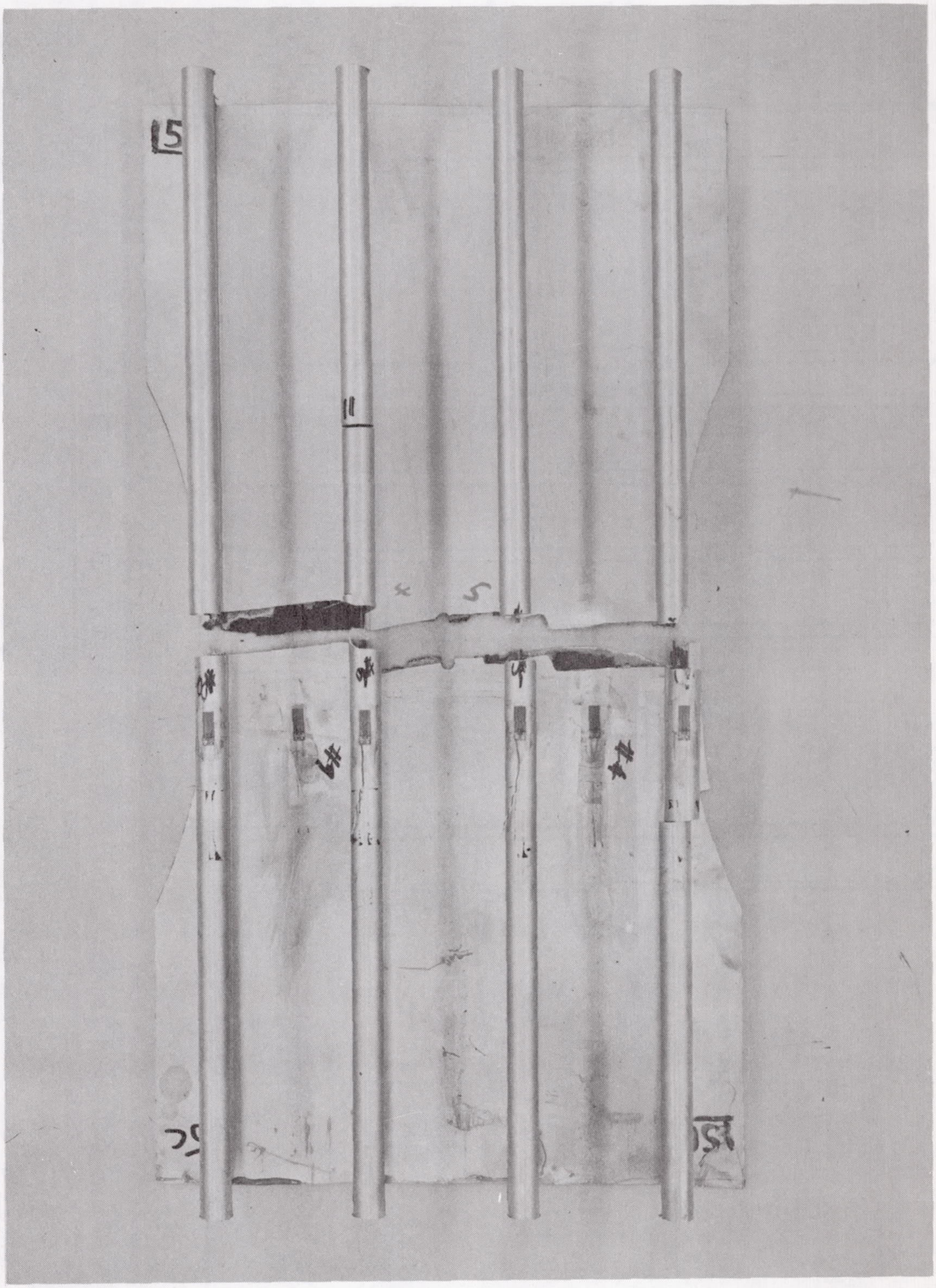

FIGURE F-60 INSIDE STIFFENER SHEET AFTER RESIDUAL STRENGTH TEST - PANEL #15C

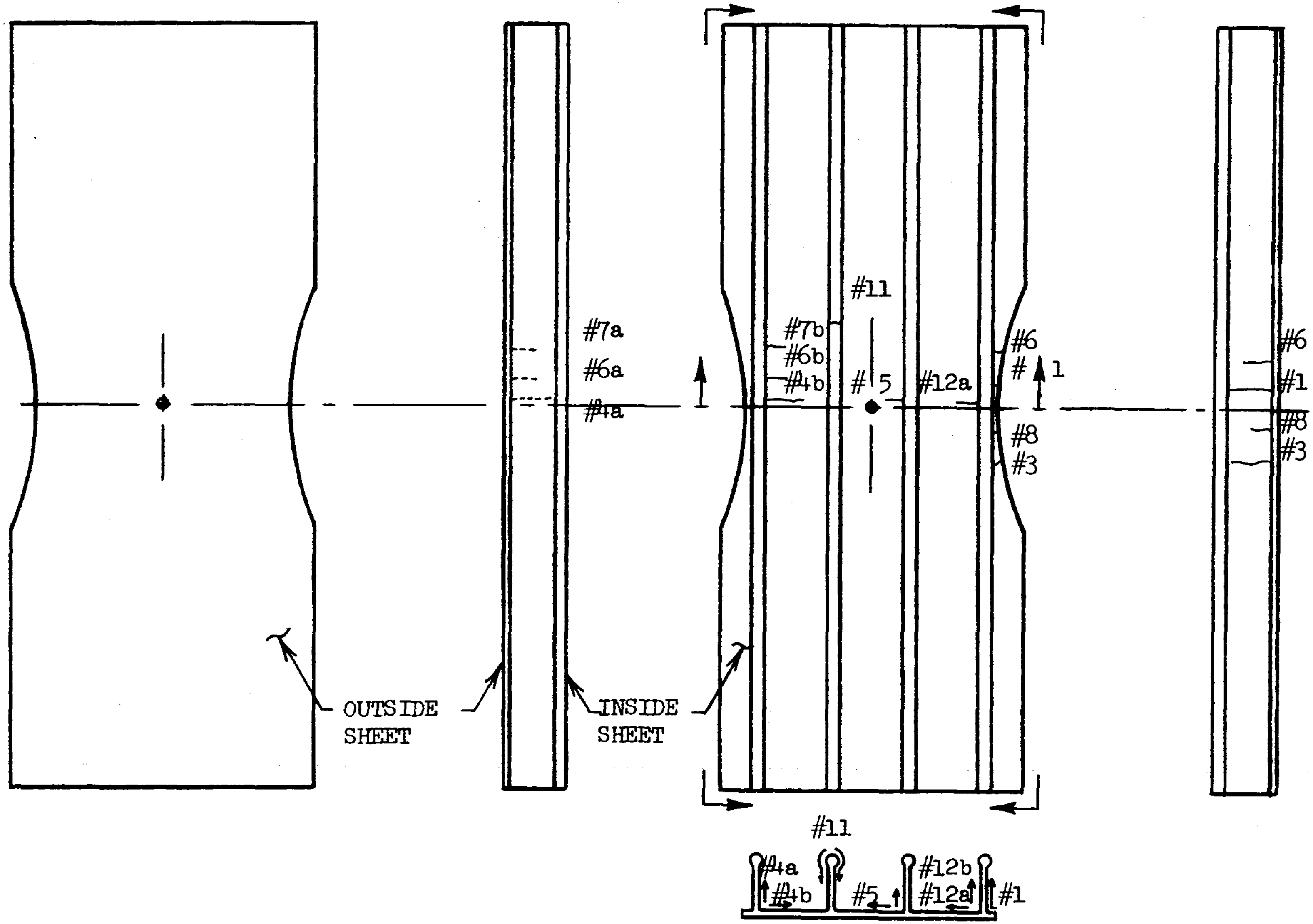

FIGURE F-61 SECONDARY CRACK LOCATIONS
ALUMINUM-GRAPHITE PANEL #15C

Panel No. 15C		Primary Crack Lengths millimeters (inches)				Secondary Crack Lengths millimeters (inches)		
Cycle Rate	No. of Cycles	L/H Outside	R/H Outside	L/H Inside	R/H Inside			
5Hz	33,009	3.8 (.15)	3.8 (.15)					
	34,009			3.8 (.15)	5.1 (.20)			
	36,809	5.1 (.20)						
	37,569			5.1 (.20)				
	38,169		5.1 (.20)					
	41,489				6.4 (.25)			
	42,029	6.4 (.25)						
	44,309		6.4 (.25)					
	47,739			6.4 (.25)				
	49,289	7.6 (.30)	7.6 (.30)					
	51,089				7.6 (.30)			
	55,519			7.6 (.30)				
	56,179	8.9 (.35)	8.9 (.35)					
	62,609	10.2 (.40)						
	65,469		10.2 (.40)					
	70,659			8.9 (.35)	10.2 (.40)			
	71,259	11.4 (.45)						
	72,609		11.4 (.45)					
	114,150	12.7 (.50)	12.7 (.50)	10.2 (.40)	11.4 (.45)			
	123,060				12.7 (.50)			
	124,170	14.0 (.55)	14.0 (.55)	11.4 (.45)				
	129,240			12.7 (.50)	14.0 (.55)			
	134,130	15.2 (.60)	15.2 (.60)					
	142,320	16.5 (.65)	16.5 (.65)					
	150,550				15.2 (.60)			
	157,450			14.0 (.55)				
	158,857	17.8 (.70)						
	161,557		17.8 (.70)					
	165,957	19.0 (.75)						
	166,157				16.5 (.65)			
	178,857			15.2 (.60)				
5Hz	181,157	20.3 (.80)						

Panel No. 15C		Primary Crack Lengths millimeters (inches)				Secondary Crack Lengths millimeters (inches)		
Cycle Rate	No. of Cycles	L/H Outside	R/H Outside	L/H Inside	R/H Inside	#1	#4a	#4b
5Hz	181,257		19.0 (.75)					
5Hz	181,657				17.8 (.70)			
6Hz	189,787	21.6 (.85)						
	189,789			16.5 (.65)				
	198,357		20.3 (.80)					
	200,257				19.0 (.75)			
	204,657	22.9 (.90)						
	213,657	24.1 (.95)	21.6 (.85)					
	213,757				20.3 (.80)			
	213,857			17.8 (.70)				
	222,627		22.9 (.90)					
	222,757	25.4 (1.00)						
	234,457	26.7 (1.05)						
	234,557		24.1 (.95)					
	235,557			19.0 (.75)	21.6 (.85)			
	238,857					15.2 (.60)	16.5 (.65)	17.8 (.70)
	249,257		25.4 (1.00)					
	252,357	27.9 (1.10)						
	252,957			20.3 (.80)	22.9 (.90)			
	255,311	29.2 (1.15)	26.7 (1.05)			17.8 (.70)	17.8 (.70)	
	257,311				24.1 (.95)			
	258,311							19.0 (.75)
	263,881					19.0 (.75)		
	263,890	30.5 (1.20)	27.9 (1.10)					
	273,311			21.6 (.85)	25.4 (1.00)	20.3 (.80)	19.0 (.75)	21.6 (.85)
	287,511			22.9 (.90)	26.7 (1.05)			
	287,711						21.6 (.85)	22.9 (.90)
	287,811					21.6 (.85)		
	288,311	33.0 (1.30)	30.5 (1.20)					
	297,211	34.3 (1.35)	31.8 (1.25)					
	299,311				57.2 (2.25)			
6Hz	304,111					22.9 (.90)		

Panel No. 15C		Primary Crack Lengths millimeters (inches)				Secondary Crack Lengths millimeters (inches)		
Cycle Rate	**No. of Cycles**	**L/H Outside**	**R/H Outside**	**L/H Inside**	**R/H Inside**	**#1**	**#4a**	**#4b**
6Hz	304,811			24.1 (.95)				25.4 (1.00)
	307,175	35.6 (1.40)						
	310,875		33.0 (1.30)					
	316,175	36.8 (1.45)			58.4 (2.30)	24.1 (.95)	25.4 (1.00)	26.7 (1.05)
	325,675	38.1 (1.50)	34.3 (1.35)					
	325,875			24.5 (1.00)	59.7 (2.35)			
	326,075						27.9 (1.10)	
	335,675	39.4 (1.55)	35.6 (1.40)					
	336,175			26.7 (1.05)	61.0 (2.40)			
	349,175	40.6 (1.60)	36.8 (1.45)		63.5 (2.50)	26.7 (1.05)		30.5 (1.20)
	358,175						29.2 (1.15)	
	358,275				64.8 (2.55)			
	359,175	41.9 (1.65)	38.1 (1.50)					
	368,175							33.0 (1.30)
	368,875			27.9 (1.10)				
	368,925		39.4 (1.55)					
	368,935					27.9 (1.10)	30.5 (1.20)	
	370,975	43.2 (1.70)						
	379,675		40.6 (1.60)					
	380,075	44.4 (1.75)						
	380,575			29.2 (1.15)	67.3 (2.65)			
	381,175						33.0 (1.30)	35.6 (1.40)
	392,175							
	393,875	45.7 (1.80)	41.9 (1.65)					
	394,175				68.6 (2.70)			
6Hz	399,467					29.2 (1.15)	34.3 (1.35)	40.6 (1.60)
5Hz	402,937	47.0 (1.85)	43.2 (1.70)	30.5 (1.20)				
	408,967		44.4 (1.75)					
	409,967							
	418,467				69.8 (2.75)			43.2 (1.70)
	419,167						35.6 (1.40)	
5Hz	422,367		45.7 (1.80)					

Panel No. 15C		Secondary Crack Lengths millimeters (inches)						
Cycle Rate	No. of Cycles	#12a	#12b					
6Hz	304,811							
	307,175							
	310,875							
	316,175							
	325,675							
	325,875							
	326,075							
	335,675							
	336,175							
	349,175							
	358,175							
	358,275							
	359,175							
	368,175							
	368,875							
	368,925							
	368,935							
	370,975							
	379,675							
	380,075							
	380,575							
	381,175							
	392,175	8.9 (.35)	10.2 (.40)					
	393,875							
	394,175							
6Hz	399,467	10.2 (.40)						
5Hz	402,937							
	408,967							
	409,967		12.7 (.50)					
	418,467	11.4 (.45)						
	419,167							
5Hz	422,367							

Panel No. 15C		Primary Crack Lengths millimeters (inches)				Secondary Crack Lengths millimeters (inches)		
Cycle Rate	No. of Cycles	L/H Outside	R/H Outside	L/H Inside	R/H Inside	#1	#4a	#4b
5Hz	422,467	48.3 (1.90)						
	429,967							
	430,667			31.8 (1.25)	71.1 (2.80)			
	431,267						36.8 (1.45)	44.4 (1.75)
	434,317	49.5 (1.95)						
	439,467		47.0 (1.85)					
	440,967					30.5 (1.20)		
	443,767			33.0 (1.30)	72.4 (2.85)			
	444,467	50.8 (2.00)						
	454,467		48.3 (1.90)					
	455,267	52.1 (2.05)						
	455,467			34.3 (1.35)	73.7 (2.90)			
	456,267							47.0 (1.85)
	456,467						38.1 (1.50)	
	460,467		49.5 (1.95)					
	461,267							48.3 (1.90)
	461,567			35.6 (1.40)				
	461,767				74.9 (2.95)			
	469,467			36.8 (1.45)	76.2 (3.00)			49.5 (1.95)
	470,467	53.3 (2.10)			Crack			
	476,867				Stopped			
	478,467	54.6 (2.15)	50.8 (2.00)		in Bulb			
	479,267				Radius		39.4 (1.55)	50.8 (2.00)
	483,765							
	489,465	55.9 (2.20)	52.1 (2.05)					
	490,965							
	491,765					31.8 (1.25)		52.1 (2.05)
	491,965						40.6 (1.60)	
	492,065			38.1 (1.50)				
	493,965	57.2 (2.25)						
	501,765		53.3 (2.10)					
5Hz	502,565	58.4 (2.30)						

Panel No. 15C		**Secondary Crack Lengths millimeters (inches)**						
Cycle Rate	**No. of Cycles**	#12a	#12b					
5Hz	422,467							
	429,967	14.0 (.55)	15.2 (.60)					
	430,667							
	431,267							
	434,317							
	439,467							
	440,967	15.2 (.60)	16.5 (.65)					
	443,767							
	444,467							
	454,467							
	455,267							
	455,467	16.5 (.65)	19.0 (.75)					
	456,267							
	456,467							
	460,467							
	461,267							
	461,567							
	461,767							
	469,467							
	470,467	19.0 (.75)	20.3 (.80)					
	476,867	20.3 (.80)						
	478,467		21.6 (.85)					
	479,267							
	483,765	21.6 (.85)	22.9 (.90)					
	489,465							
	490,965		25.4 (1.00)					
	491,765							
	491,965							
	492,065							
	493,965							
	501,765							
5Hz	502,565							

Panel No. 15C		Primary Crack Lengths millimeters (inches)				Secondary Crack Lengths millimeters (inches)		
Cycle Rate	No. of Cycles	L/H Outside	R/H Outside	L/H Inside	R/H Inside	#1	#4a	#4b
5Hz	505,265			39.4 (1.55)				
5Hz	506,465							53.3 (2.10)
FINAL CRACK LENGTHS		58.4 (2.30)	53.3 (2.10)	39.4 (1.55)	76.2 (3.00)	31.8 (1.25)	40.6 (1.60)	53.3 (2.10)
	RESIDUAL	STRENGTH =	351,400N	(79,000 lbs)				

Panel No. 15C		Secondary Crack Lengths millimeters (inches)						
Cycle Rate	No. of Cycles	#12a	#12b					
5 Hz	505,265							
5 Hz	506,465							
FINAL CRACK LENGTHS		21.6 (.85)	25.4 (1.00)					

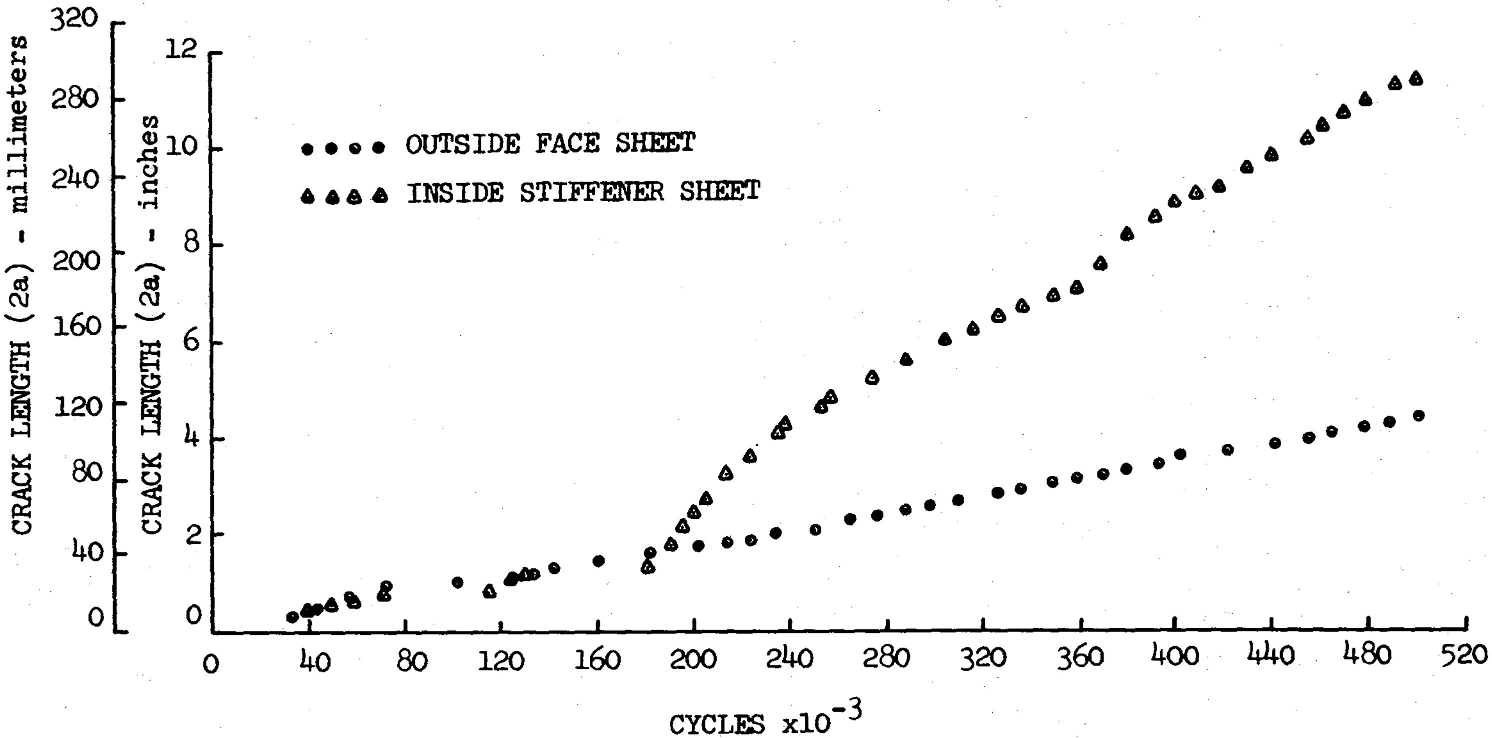

FIGURE F-62 CRACK GROWTH CURVE FOR ALUMINUM-GRAPHITE PANEL #15C
(Crack Length Includes Secondary Cracks)

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